Southwest Fisheries Center Administrative Report H-89-2C

LINEAR PROGRAMMING MODEL
FOR THE
NORTHWESTERN HAWAIIAN ISLANDS BOTTOMFISH FISHERY

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January 1989

NOT FOR PUBLICATION

This Administrative Report is issued as an informal document to ensure prompt dissemination of preliminary results, interim reports, and special studies. We recommend that it not be abstracted or cited.

PREFACE

This report was prepared under contract Number 87-P-9 to the Western Pacific Regional Fishery Management Council (Council) in cooperation with the Honolulu Laboratory, National Marine Fisheries Service (NMFS). The work was supervised by Samuel G. Pooley, NMFS. Data acquisition was facilitated by Kurt Kawamoto, NMFS.

The Lotus 1-2-3 spreadsheet used in this project is freely available, but the LP83 linear programming computer program is a proprietary software package available only from its manufacturer. [Use of trade names does not imply NMFS or Council endorsement.]

To expedite circulation, this Administrative Report only reproduces those sections of the Appendixes required for understanding the basic model and its results. A complete project Appendix is available on request.

Because this report was prepared independently under contract, its findings and conclusions do not necessarily represent the National Marine Fisheries Service.

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LINEAR PROGRAMMING MODEL FOR THE NWHI BOTTOMFISH FISHERY

I. INTRODUCTION

This report is part of an Economic Profile of the Northwestern Hawaiian Islands (NWHI) Bottomfishery (NA-87-ABH-00024) prepared under contract (No. 87-P-9) to the Western Pacific Regional Fishery Management Council (Council).

The purpose of this project was to develop a linear programming (LP) model for the NWHI bottomfish fishery that would enable fishery managers to improve their utilization of available biological and economic data in formulating bottomfish management strategies. The model permits a range of management regimes to be evaluated. This report outlines the model and describes its various components. Full results from using the model will be included in subsequent reports.

II. DEFINITION OF LINEAR PROGRAMMING

The term "linear programming" usually creates the misconception of writing computer instructions or code. It is instead a mathematical planning process. A better term to use may be "linear planning" or "optimization with linear constraints." [Ref. 1, p. 3]

Linear programming was defined initially by Danzig (1947) as a type of mathematical modeling that solves problems in which the various components have proportional relationships to the solution outcome and to each other. This means that:

(1) If there is a change in one activity, it will cause a proportionate change in the results; e.g., doubling the revenue produced by one variable (activity) will cause the total revenue to increase by twice this variable's original effect.

(2) Interactions among the variables are additive; e.g., the total amount of the resources used will be equal to the sum of the resources used by each activity.

(3) Solution values for the activities are continuous; e.g., there may be fractional (62.4) solution values assigned to the variables. [Ref. 2, p. 3]

Additionally, the activity levels (variables) in a linear programming problem are limited by inequality constraints or side conditions: bounds that set a maximum or a minimum value that the solution cannot breach, but otherwise allow a range of possible answers. LP is used in a situation where a number of often diverse inputs (frequently constrained in their total availability) are combined to generate a flow of benefits (also often constrained in some way). [Ref. 3, p. 7]

III. PURPOSE OF A LINEAR PROGRAM ANALYSIS

An LP model is technical aid in making decisions about the allocation of limit resources among competing activities so as to obtain the greatest possib. efficiency in use of the resources. "Limited resources" may be raw materials, labor, capital, processing time, etc. The procedure analyzes the present and projected demand for the limited resource, evaluates the impact all of the competing activities will have on it and arrives at one "best" solution out of many possibilities. The "best" choice is not always obvious -- especially when many variables or competing activities are feasible and there are complicated or interwoven constraints. An optimal solution must be found that does not violate the limitations imposed by the various inequality conditions while producing a given objective. This objective is to either maximize some measure of benefit or utility such as profit or minimize some measure of loss such as cost. [Ref. 4, p. 7]

A solution usually is not determined by the LP83 program in one iteration. There is a systematic trial-and-error procedure that searches for the "best" values of each competing activity that, when taken together, produce the desired objective; i.e., least cost or greatest profit for the whole array of activities. The system follows these rules.

(1) The results of each trial are used as the basis in determining what the next trial will be. Trials are directly related to each other. This is very important for efficient analysis when a great number of variables with attendant interrelationships are involved. Otherwise, one could proceed in an endless circle.

(2) The method is constructed so that each trial will yield values which are closer than the preceding result to an optimal (best) answer. This prevents wasting time going in a wrong direction. [Ref. 5, p. 76]

In a geometric delineation of the process, the LP83 starts from some corner point (vertex) of the feasible range (typically a polyhedron-shaped area) of solution values and with each trial (iteration) it searches for a neighboring vertex with a better value of the objective function. If none is found, the current vertex value becomes the optimum solution. [Ref. 1, p. 17-18]

Although linear programming is mathematically complex, its principles are relatively simple. It is frequently used in business applications for scheduling and distribution problems, and for financial allocation models in investment. A current example is its use in the choice of "hub" locations for airlines and air freight companies. Application of linear programming to fisheries is essentially an allocation problem.

IV. APPLICATION OF LINEAR PROGRAMMING TO THE NWHI BOTTOMFISH FLEET PROJECT

A general linear programming model for the Hawaii fishery was developed by Dr. Dennis M. King of E.R.G. Pacific Inc. under contract to the National Marine Fisheries Service (NMFS), Honolulu Laboratory [Ref. 6]. The model runs on a microcomputer using the LP83 commercial software package by Sunset Software [Ref. 4]. This software package's principal features are described in Appendix A. The general Hawaii fishery model has a number of <u>different</u> (i.e. non-bottomfish) fleets fishing for a number of target species (not limited to bottomfish). Seven submodels were subsequently created for the Hawaii fishery based on various permutations of the constraints utilized in the general model (primarily variations on fixed cost accounting).

Data acquisition for the general Hawaii fishery model was limited because of funding constraints. As a result, a modified Delphi process was used by the industry economist, Honolulu Laboratory, NMFS, to develop baseline catch rate, cost, price, and other parameter values. These data were incorporated into King's general model for the Hawaii fishery, but the model was not fully tested prior to this project.

As an initial part of the present contract, a basic version of the general Hawaii model was modified in both data and operational terms to better replicate conditions in Hawaii. These results will be reported separately.

The major part of this contract involved developing a model specifically for the NWHI bottomfish fleet. Elements for this model were determined in consultation with the NMFS Honolulu Laboratory's Fishery Management Research Program and the Council's Bottomfish Plan Monitoring Team. Data were derived from NMFS Honolulu Laboratory fishery management and economic research files.

One management strategy being implemented by the Council is limiting entry of boats into the NWHI bottomfish fishery. [Dr. King recently created an LP for NMFS use in analyzing limited entry possibilities for the west coast groundfish industry (Ref. 7).] The objectives of this strategy are to reduce the risk of overcapitalization by new entrants, increase stability and profitability for boat owners and fishermen already engaged in the fishery, and control damage to NWHI bottomfish stocks from overfishing. Given these objectives, the NWHI bottomfish LP model was designed to maximize fleetwide profitability for the number and type of vessels that actively landed bottomfish in 1987.

The problem to be addressed is managing the NWHI bottomfishery so as to optimize the net overall (Fleetwide) revenue without damaging the resource supply (fish stocks). In 1987 this fishery consisted of 4 Fleet (boat) types -- (1) large, multipurpose; (2) medium, multipurpose; (3) tuna longliner and troller; and (4) motor-sailer. Each boat in a Fleet can target any of 3 Species groups. Species 1 is predominately opakapaka and onaga which are preferred (high value) bottomfish. Species 2 covers all other bottomfish (those not included in the Species 1 category). Species 3 represents a predominately pelagic catch (tuna, ono, mahimahi).

Most boats can fish in any of 4 Areas -- (1) Main Hawaiian Islands; (2) Mau; (3) Lower Hoomalu; and (4) Upper Hoomalu. The one exception is that medium, multipurpose vessels cannot travel as far as the Upper Hoomalu area. Fishing can take place during any of 3 Seasons. Season 1, classified as Holiday, includes January and December. Season 2, Summer, covers the months of May through August. Season 3, Winter, encompasses all the remaining months (February through April and September through November). The amount of fishing time available per season is limited by the number of calendar days in that season and the amount of time needed by boat captains to prepare the boat and travel to a fishing area.

Various input parameters such as operating costs, catch rates and fish market prices differ depending on vessel type, target species, fishing area and season. The price assigned for a Species reflects the average market price received during the given 1987 Season. There is a limited amount of each bottomfish Species available in an Area.

The objective of the NWHI Bottomfish LP model is to maximize industry (Fleetwide) profits. LP83 uses the input parameters of this model to solve the problem of how to apportion the limited number of fishing days available in each Season (while not exceeding the Species poundage allowed for each area) among the numerous potential combinations of boat type, species, area and season so as to achieve this objective. Only combinations with the most favorable resource and economic mix are assigned fishing days. This means that some combinations are excluded from fishing. At times, a solution may be returned by LP83 that passes over a particular vessel type, species, season or area entirely. Thus, it is obvious that the model does not reproduce reality or propose "real" solutions. Instead it sets a baseline for measuring changes in the various parameters.

The idea in a fisheries LP application is to show how fishing effort (fishing days) would be applied in different areas and seasons to maximize industry-wide net revenues. [Net revenue is calculated as the total revenue (catch rate <u>times</u> fish price <u>times</u> number of fishing days) <u>minus</u> the total cost of fishing (operating costs per day at sea <u>times</u> number of days at sea, <u>plus</u> the annual fixed costs). A simple example of a linear programming problem in fisheries is shown in Appendix B.]

The calendar in this model is divided into three seasons, each of whose total days has a subset number of fishing days available. The project goal is to determine the best way to distribute these fishing days among the E variables (fishing situations) which represent combinations of vessel type, species, area and season. In addition to these fishing day limits, there are also constraints on the availability of a species in a given area.

Net revenue in different fishing areas and seasons is not the same, but not all fishing effort can be applied to the single most profitable area-season combinations because of constraints on the amount of available fish. Thus, whenever the number of choices in applying fishing effort becomes great, the solution is practically impossible to visualize. Indeed, one of the greatest difficulties with linear programming is depicting the detail of its results (rather than just the total maximized net revenue and the number of fishing vessels in the solution). The solution usually differs from the real world because of two factors: (1) open-access fisheries tend toward over-capacity (and thus minimization of industry-wide profits); and (2) the linear program software employs the simplex methodology which does not allocate fishing effort evenly across the feasible range of time and space, but tends to lump it at the smallest possible number of profitable times and spaces (the corner points or vertices of this range).

A full mathematical specification of the linear programming problem can be found in Reference 6, under Exhibit 2, on pages 14-15.

V. LIMITATIONS OF THE LINEAR PROGRAMMING METHODOLOGY

Linear programming is an aid to better understanding of a specific situation. **It should not be used as a direct substitute for management decisions.** The results of an LP analysis can help to find implications of available economic information or economic assumptions. As with all computer programs, the Garbage In, Garbage Out (GIGO) principle applies. The outcome will only be as reliable as the data provided. In order to represent a real-world situation, this data should be as accurate as possible when assigning values to various model parameters. It is acceptable to synthesize some data elements, but too much synthesis may negate the value of the solution. If data are of doubtful value, or if the LP model is not appropriate for the problem under consideration, then LP results may create greater confusion rather than clarifying a situation. [Ref. 8, p. 3]

The situation being analyzed must fit the following assumptions required by any LP software package. [Ref. 3, p. 131-144]

* The objective or goal is explicit.
  (i.e. increase fishery revenue)

* Optimization of the objective is desired.
  (i.e. maximize fleetwide profit)

* Relationships among the model's components are linear.
  (i.e. total profit = sum of boat profits)

* Activities have limits or constraints that partially restrict the range of their solution value.
  (i.e. quantity of Species 1 in Area 1 <= 94000 lbs)

* Parameters (resource supply and usage, control of activities, etc.) are known with certainty.
  (i.e. daily operating cost for Fleet 1 to catch Species 1 in Area 1 during winter = $244)

Defining the goal or objective of the model is to some extent subjective. Managers may not be able to agree on a specific objective (required by the LP) as each comes with a different role, philosophy, and background information which influences this decision. Should the model maximize profit? minimize costs? maximize use of resources? minimize political turmoil? It is quite possible to have two or more objectives -- some of which are not compatible. Several versions of the model with different objectives may be needed. [Ref. 8, p. 4]

Deciding on what essential activities to include in the model, relevant activity parameters and their values, and what reasonable constraints or limits to place on the activities are other critical areas where agreement is necessary but often difficult to achieve. If these components are ill-defined or are of an uncertain nature, confidence in the solution values will be compromised. In any case, the problem must be quantified.

The assumption of knowing parameter values with certainty (one of the LP requirements) is unrealistic. For most of the Bottomfish LP model's parameters, these values (catch rates, fish prices, operating costs, etc.) are averages and "guesstimates." They do not represent the real-life extremes or ranges that contribute to the averages, nor do they include a broad base of opinion for the estimated data. Additionally, any input value may change in response to new real-world situations. However, the LP software package analyzes these values as if they were static or unchanging [Ref. 3, p. 141]. **This is the principal reason why the results or solution values returned by an LP analysis <u>cannot</u> be taken as directly applicable to real-world situations.** At best, they are snap-shot quality indicators of what would have been optimal resource usage within an environment mirroring that of the LP model.

VI. DESCRIPTION OF THE NWHI BOTTOMFISH LINEAR PROGRAMMING SPREADSHEET

The NWHI Bottomfish LP model functions through the LP83 commercial software package. This package runs on a 16-bit microcomputer and can use a Lotus 1-2-3 spreadsheet as the data entry file. Input spreadsheets are designed to present the basic parameters of the LP problem to be solved in an organized manner. A math co-processor is also employed with LP83 for increased processing efficiency.

The following narrative explains the various parts of the NWHI Bottomfish LP baseline model (BASEBTM). BASEBTM can be found in Appendix C. It has been printed in standard format for inclusion in this report. To use Item C1 with the discussion below, pages C1.1 - C1.5 should lay side by side with page C1.6 <u>below</u> page C1.1. Most of the spreadsheet is composed of the long variable list and its associated parameters. For brevity, this repetitive middle section [cells AW through EF] has not been printed. Page C1.7 is at the far right side of the spreadsheet showing the end of the Data and Constraints Sections.

Item C1 is the data entry spreadsheet with its numeric values. Item C2 is the same spreadsheet showing the equations involved in this model's basic relationships that produce these values. LP83 requires certain range names (identified by the prefix "83") to be incorporated within an input spreadsheet. Additionally, range names have been given to many other individual cells and groups of cells for convenience. A complete list of the range names and their cell locations is included as item C3.

A. <u>Title Section</u>

Although not a necessity, having a title as the first element in each spreadsheet enables the user to keep track of what a specific version does. [Note: Asterisks (*) before or around a statement indicate a comment which will be ignored by the LP83 program during execution. The top row of letters and the left-hand column of numbers in the display are the Lotus 1-2-3 cell references.] The spreadsheet is called the NWHI Bottomfish Model -- Baseline Version (cells G2 to K2) with BASEBTM.WKS (cell B2) being the name of this file as listed in the Lotus directory.

A	B	C	D	E	F	G	H	I
2	BASEBTM.WKS		** TITLE SECTION **			NWHI Bottomfish Model		

B. Operating Environment Section

This section encompasses a large, rectangular area from cell D4 through cell AT30. It defines all of the components that contribute to the essential elements and activities (variables), but it is not directly used by the LP83 software. Some parts (given range names described later) will be incorporated into regions of the spreadsheet that are used by the LP83 program.

Activity variables beginning with the letter E (for fishing Effort in bioeconomic parlance) represent all the viable permutations of fleet type, fish species, area and season that are possible within the context of this problem. They are organized in the following manner:

$$E_{ijkm}$$

where i = Fleet (boat) type;
j = Fish Species;
k = Area; and
m = Season.

The K variables reflect a Fleet's size. K_{i---} represents the number of boats participating in Fleet (i). Currently, no differentiation is made as to the number of boats that would be optimal in each situation which means Fleet size is the same in all situations. Since j, k, and m are not influencing Fleet size in the bottomfish models, they have been replaced by dashes. The model could be modified to reflect any influence fishing for a particular species (j), or in a certain area (k), or during a given season (m), may have on the optimal number of boats in a Fleet that should be included in a fishing situation (E variable).

The various Fleet types (the i's) in the NWHI bottomfish fishery are presented in the section bounded by cells E7 through H10. These are:

(i) = 1 - large, multipurpose;
(i) = 2 - medium, multipurpose;
(i) = 3 - tuna-longline and troller; and
(i) = 4 - motor-sailer.

A	B	C	D	E	F	G	H	I
2								
3								
4			** OPERATING ENVIRONMENT SECTION **					
5								
6					FLEET SIZE	MINIMUM	MAXIMUM	
7				FLEET 1 =	Large Multipur	3	6	
8				FLEET 2 =	Medium Multipur	1.5	3	
9				FLEET 3 =	Tuna Longline	7.5	15	
10				FLEET 4 =	Motor-Sailers	2	4	
11						Minimum =	0.5	

The Fleet categories are imprecise classifications of the existing Bottomfish fishery in Hawaii. Categorization is based on catching power and fishing costs. Three categories are purely diesel powered vessels while one category also has sails. The large, multipurpose vessels are modern boats over 60 feet in length. These vessels can engage in other types of fishing, and many have come to Hawaii from the Pacific northwest. The medium, multipurpose vessels are smaller versions of the first category. Their length is 50 feet. Many were constructed specifically for the NWHI bottomfish industry. Tuna longliners and trollers are also modern vessels whose primary target species are bigeye and yellowfin tuna. However, they can shift into the bottomfish fishery relatively easily. Motor-sailers are similar in many ways to the medium, multipurpose vessels, but they have different cost characteristics because of their sail power.

In BASEBTM (the baseline LP model), the maximum number of vessels under each type (cells H7 to H10) represents the number of boats in that category actively landing bottomfish in 1987. Each of these maximum values has been given a range name composed of FLT and the appropriate Fleet number.

EXAMPLE: FLT1 (cell H7) = maximum number of boats in FLeeT 1.

In order to ensure that some boats of each kind are included in the solution, a minimum number of vessels (cells G7 to G10) has been set as one-half of the maximum vessel number. This is an additional constraint to the baseline LP model designed to better represent real-world conditions. The equations for these constraints are shown below (copied from Item C2 of Appendix C). The minimum number of boats for Fleet 1 (cell G7) equals FLT1 (range name described above) multiplied (*) by the contents of cell H11 (0.5). All of these minimum boat values have also been given range names of the form FLTO plus the Fleet number.

EXAMPLE: FLTO1 (cell G7) = minimum number of boats in FLeeTO 1.

A	B	C	D	E	F	G		H
4			** OPERATING ENVIRONMENT SECTION **					
5								
6					FLEET SIZE	MINIMUM		MAXIMUM
7				FLEET 1 =	Large Multipur	+FLT1*H11		6
8				FLEET 2 =	Medium Multipur	+FLT2*H11		3
9				FLEET 3 =	Tuna Longline	+FLT3*H11		15
10				FLEET 4 =	Motor-Sailers	+FLT4*H11		4
11							Minimum =	0.5

[Note: Both the minimum and maximum fleet configurations are easily changed. Setting a minimum number of boats for each Fleet that must be given some fishing time is a political decision. In the Results Section of this report, a trial (BTM5) is described where no minimums were set for any Fleet; i.e., FLTOi = 0.]

Under SPECIES (cells J7 through K9) are listed the three categories into which all of the various bottomfish and pelagic fish caught by the bottomfish vessels have been grouped for use as the second alpha-numeric element in a variable (the j's). These categories reflect the predominate species in what are usually composite catches.

(j) = 1 - opakapaka, onaga (preferred bottomfish).
(j) = 2 - all other bottomfish.
(j) = 3 - pelagic fish (tuna, mahimahi, and ono).

A	J	k	L
6	SPECIES		
7	SPECIES 1 = OPAKA,ONAGA		
8	SPECIES 2 = ALL OTHER BOTTOMFISH		
9	SPECIES 3 = ALL PELAGICS		

Fishing Areas (cells N7 through P10) represent the third alpha-numeric element (the k's) in each variable. They correspond to the Council's basic fishery management areas. Fishing areas 2 - 4 are in the Northwestern Hawaiian Islands, a considerable distance from Honolulu. [See Figure 1: a map of the Hawaiian Archipelago.]

(k) = 1 - Main Hawaiian Islands (to 161° W).
(k) = 2 - Mau (161° to 165° W).
(k) = 3 - Lower Hoomalu (165° - 170° W).
(k) = 4 - Upper Hoomalu (170° - 180° W).

A	M	N	O	P	Q
5					
6		FISHING AREAS			
7	AREA 1 = Main Hawaiian Islands (to 161°)				
8	AREA 2 = Mau (161°-165°)				
9	AREA 3 = Lower Hoomalu (165°-170°)				
10	AREA 4 = Upper Hoomalu (170°-180°)				

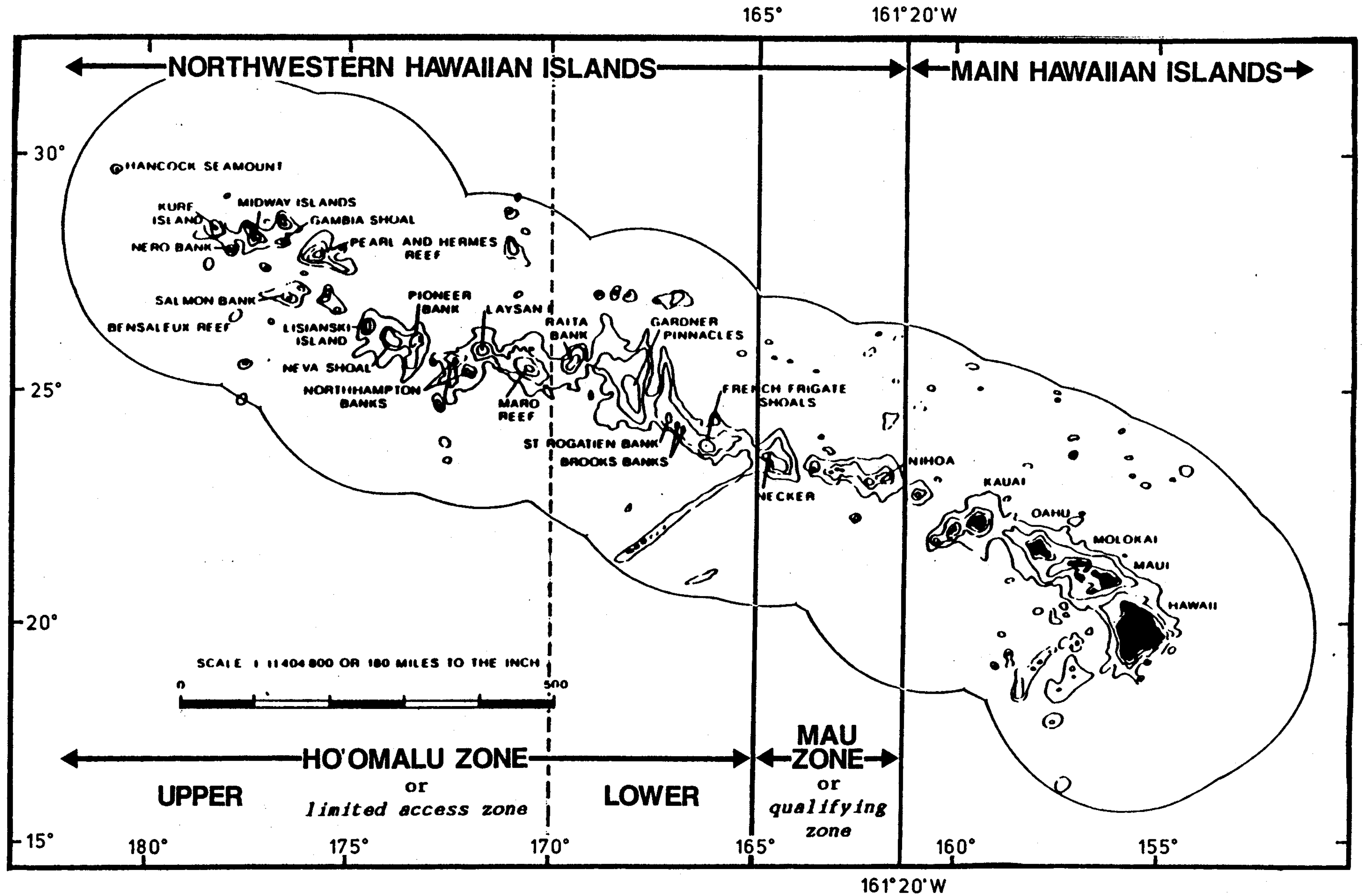

Figure 1.--Hawaiian Archipelago.

The last element in a variable (the m's) indicates a SEASON (cells R7 through S9) which is defined by both weather and market demand characteristics. Immediately to the right of this section are the calendar days in each season (cells U7 through W7). Range names for these values are:

(m) = 1 - SEAH (cell U7) = SEAson Holiday [Dec-Jan];
(m) = 2 - SEAS (cell V7) = SEAson Summer [May-Aug]; and
(m) = 3 - SEAW (cell W7) = SEAson Winter [Feb-Apr & Sep-Nov].

A	Q	R	S	T	U	V	W
2							
3							
4							
5							
6		SEASONS			CALENDAR DAYS PER SEASON		
7		Holiday =	1		60	120	180
8		Summer =	2		Dec-Jan=1	May-Aug=2	Feb-Apr
9		Winter =	3				Sept-Nov=3
10							

EXAMPLE: E1342 is the fishing Effort (in number of fishing days) of Fleet 1 (large, multipurpose vessels) catching Species 3 (pelagics) in Area 4 (Upper Hoomalu) during Season 2 (Summer: May - Aug.).

FISH DAYS PER TRIP (cells Z8 through Z11) are values assigned to each Fleet (1-4) on the basis of an average number provided by the captains of various boat types who were interviewed. Each value has a range name with the format shown in brackets []. This acronym stands for Average Fishing Day Fleet i (number).

EXAMPLE: AFDF1 (cell Z8) = average number of fishing days per trip for Fleet 1.

		Y	Z	AA
6		FISHING DAYS PER TRIP		
7		(ANNUAL AVERAGE) [AFDFi]		
8	FLEET 1		14	
9	FLEET 2		10	
10	FLEET 3		14	
11	FLEET 4		14	

RUNNING DAYS BY AREA PER TRIP (cells AD7 through AH12) consist of <u>three number sets</u>.

		AD	AE	AF	AG	AH	AI
6		RUNNING DAYS BY AREA PER TRIP [RDiAi]					
7		MHI	MAU	LOWER	UPPER	AVERAGE [ARDFi]	
8	FLEET 1	2	5	6	8	5.3	
9	FLEET 2	2	6	7	-	5.0	
10	FLEET 3	2	5	6	8	5.3	
11	FLEET 4	2	7	8	10	6.8	
12		2.0	5.8	6.8	8.7	5.6	

<u>Set one</u> (cells AD7 through AG11) identifies the four areas (MHI = Main Hawaiian Islands, etc.) and under each abbreviated title lists the average number of running days (travel time) per trip for each Fleet type (1-4). These averages were also obtained from personal interviews with boat captains. [Note: Boat type 2 (medium, multipurpose) does not travel into Upper Hoomalu (area 4), hence there is a dash mark for that entry.]

<u>Set two</u> (cells AD12 - AG12) is the column average or average number of running days of all boats to each area.

<u>Set three</u> (cells AH7 - AH11) presents the row average or average number of running days of all areas taken together for each Fleet type (1-4). The last entry (cell AH12) is the total average or the average running day of any boat type to any area. [See item C2 for the equations creating these column and row averages.]

Range names given to each value in set one have the format (in brackets) RDiAi which stands for <u>R</u>unning <u>D</u>ays for fleet number <u>i</u> to <u>A</u>rea number <u>i</u>.

EXAMPLE: RD1A1 (cell AD8) = the running days needed for fleet 1 to go to area 1

Range names were also given to values in the AVERAGE column (cells AH8 to AH11). This format is ARDFi meaning <u>A</u>verage <u>R</u>unning <u>D</u>ay for <u>F</u>leet <u>i</u> (number).

EXAMPLE: AFDF1 (cell AH8) = overall average running days for fleet 1 to any area

The next section to the right is POTENTIAL TRIPS PER SEASON (cells AK9 through AM12). The values for each fleet type under each season were calculated from a formula that divides the calendar days in a given season [using the range names under Calendar Days (cells U7-W7)] by the total average operating days per trip by fleet and season [range names with format ODii (cells P17 - R20)]. The form for range names in this section is PTii.

EXAMPLE: PT11 (cell AK9) - Potential Trips of fleet 1 in season 1

	AJ	AK	AL	AM
6		POTENTIAL TRIPS [PTii]		
7		PER SEASON		
8		Holiday	Summer	Winter
9	FLEET 1	2.7	4.0	8.5
10	FLEET 2	3.0	4.5	8.3
11	FLEET 3	2.7	4.0	8.5
12	FLEET 4	2.3	3.5	6.7

[Note: Fractional values occur due to the linearity feature of LP83. If no fractions are desired, one can specify the integer only option before a trial run.]

The last section of the top group lists the ANNUAL FIXED COSTS PER VESSEL (cells AP8 through AQ11). These numbers are an average "best estimate" of expenses not included under daily operating costs (c) based on personal interviews with boat owners. The range names (format FCVi) for this section represent fixed costs per vessel in a Fleet type.

EXAMPLE: FCV3 (cell AP10) - Fixed Costs per Vessel in fleet 3

	AO	AP	AQ	AR
6		ANNUAL FIXED COSTS [FCVi]		
7		(PER VESSEL)		
8	FLEET 1	75000		
9	FLEET 2	60000		
10	FLEET 3	75000		
11	FLEET 4	50000		

The second level of operating environment description begins with TOTAL POTENTIAL FISHING DAYS PER BOAT PER SEASON (cells F14 through I20). The values in this set are the result of multiplying the appropriate fleet/season Potential Trips [range names PTii in cells AK9 through AM12] by its fleet/season counterpart in Average Fishing Days per Trip (range names FDii in cells Z17 through AB20). Range names given to this set have the form FiSi (cells G17 through I20).

EXAMPLE: F1S1 - potential fishing days available for <u>F</u>leet <u>1</u> in <u>S</u>eason <u>1</u>

A	B	C	D	E	F	G	H	I
14						TOTAL POTENTIAL FISHING		
15						DAYS PER BOAT PER SEASON [FiSi]		
16					SEASON	1=Holiday	2=Summer	3=Winter
17		FLEET 1			Large Multipur	38	84	90
18		FLEET 2			Medium Multipur	30	67	62
19		FLEET 3			Tuna Longline	38	84	90
20		FLEET 4			Motor-Sailers	33	74	70

The next section to the right is TOTAL POTENTIAL OPERATING DAYS PER SEASON (cells K14 through M20). These values represent the Potential Trips (range names PTii in cells AK9-AM12) <u>times</u> the Average Operating Days per Trip (range names ODii in cells P17-R20) within the appropriate fleet by season category. Range names for this section have the format OFiSi (in brackets).

EXAMPLE: OF1S1 - potential <u>O</u>perating days for <u>F</u>leet <u>1</u> in <u>S</u>eason <u>1</u>

	J	K	L	M
14		TOTAL POTENTIAL		
15		OPERATING DAYS PER SEASON [OFiSi]		
16		Holiday	Summer	Winter
17	FLEET 1	60	120	180
18	FLEET 2	60	120	180
19	FLEET 3	60	120	180
20	FLEET 4	60	120	180

Under AVERAGE OPERATING DAYS per trip (cells P17 through R20) the sum of the Average Fishing days per trip (range names FDii in cells Z17 through AB20), Average Running Days per Trip (range names RDii in cells AE17 through AG20), and Average Turn-Around Days per Trip (range names TDii in cells U17 through W20) is calculated for each fleet by season combination. [Equations copied below are from Item C2 of Appendix C.] An Annual Average (row 22) is given which is equal to the average of all values in this set. It will be used in other calculations. Range names for this section are of the form ODii.

EXAMPLE: OD11 = average Operating Days per trip for fleet 1 in season 1

	O	P	Q	R
14		AVERAGE (PER TRIP)		
15		OPERATING DAYS [ODii]		
16		Holiday	Summer	Winter
17	FLEET 1	22.3	29.9	21.1
18	FLEET 2	20.0	26.8	21.8
19	FLEET 3	22.3	29.9	21.1
20	FLEET 4	25.8	34.1	26.9
21				
22	Annual Average =		25.1	

	P	Q	R
14	AVERAGE (PER TRIP)		
15	OPERATING DAYS [ODii]		
16	Holiday	Summer	Winter
17	+FD1H+RD1H+TD1H	+FD1S+RD1S+TD1S	+FD1W+RD1W+TD1W
18	+FD2H+RD2H+TD2H	+FD2S+RD2S+TD2S	+FD2W+RD2W+TD2W
19	+FD3H+RD3H+TD3H	+FD3S+RD3S+TD3S	+FD3W+RD3W+TD3W
20	+FD4H+RD4H+TD4H	+FD4S+RD4S+TD4S	+FD4W+RD4W+TD4W
21			
22	Annual Average =	@AVG(P17..R20)	

AVERAGE TURN-AROUND DAYS per trip (cells U17-W20) are given values representing a "best guess" estimate from personal interviews with the fishermen. The format for range names in this section is TDii (in brackets).

EXAMPLE: TD11 - average Turn-around Days for fleet 1 in season 1

	T	U	V	W
14			AVERAGE (PER TRIP)	
15			TURN-AROUND DAYS [TDii]	
16		Holiday	Summer	Winter
17	FLEET 1	3	5	4
18	FLEET 2	5	8	8
19	FLEET 3	3	5	4
20	FLEET 4	5	8	8

AVERAGE FISHING DAYS per trip (cells Z17-AB20) are calculated by multiplying the fleet Annual Average Fishing Days per trip (range names AFDFi in cells Z8-Z11) by a rate value (given below the appropriate column in row 22) for that season. These rates are an estimate of seasonal influence on the number of fishing days per trip. Most boats take shorter trips during winter months due to stormy, high-wind weather conditions. They tend to stay out longer in the summer months. Range names with format FDii were given to values in this set.

EXAMPLE: FD11 - average Fishing Days for fleet 1 in season 1

	Y	Z	AA	AB
6		FISHING DAYS PER TRIP		
7		(ANNUAL AVERAGE) [AFDFi]		
8	FLEET 1	14		
9	FLEET 2	10		
10	FLEET 3	14		
11	FLEET 4	14		
12				
13				
14			AVERAGE (PER TRIP)	
15			FISHING DAYS [FDii]	
16		Holiday	Summer	Winter
17	FLEET 1	14.0	21.0	10.5
18	FLEET 2	10.0	15.0	7.5
19	FLEET 3	14.0	21.0	10.5
20	FLEET 4	14.0	21.0	10.5
21				
22	RATE =	1.00	1.50	0.75

AVERAGE RUNNING DAYS per trip (cells AE17-AG20) result from multiplying the appropriate fleet AVERAGE running days by area (range names ARDFi in cells AH8-AH11) by the rate given below each column in row 22. These rate values are an estimated adjustment for the seasonal differences in travel time required per trip. It usually takes longer to travel a given distance in winter months when seas are high and rough due to storms. Range names with the format RDS(season letter) were assigned to the three rate numbers.

EXAMPLE: RDSH (cell AE22) = Running Day ratio for Season Holiday

The values of this set have range names with format RDii (in brackets).

EXAMPLE: RD11 (cell AE17) = average Running Days for fleet 1 in season 1

	AD	AE	AF	AG	AH
14			AVERAGE (PER TRIP)		
15			RUNNING DAYS [RDii]		
16		Holiday	Summer	Winter	
17	FLEET 1	5.3	3.9	6.6	
18	FLEET 2	5.0	3.8	6.3	
19	FLEET 3	5.3	3.9	6.6	
20	FLEET 4	6.8	5.1	8.4	
21					
22	RATE =	1.00	0.75	1.25	

ACTUAL TRIPS per Boat PER SEASON (cells AK18 through AM21) are derived from dividing the appropriate fleet/season Actual Fishing Days per boat (cells G25-I28) by the concomitant fleet/season Average per trip Fishing Days (range names FDii in cells Z17-AB20). These values are not used in any calculations but are included for comparison with the Potential Trips numbers in the section above (same column). The numbers should be similar if LP83 uses all available fishing days.

	AJ	AK	AL	AM
15		ACTUAL TRIPS (PER BOAT)		
16			PER SEASON	
17		Holiday	Summer	Winter
18	FLEET 1	2.7	4.0	8.5
19	FLEET 2	3.0	4.5	8.3
20	FLEET 3	2.7	4.0	8.5
21	FLEET 4	2.3	3.5	6.7

AVERAGE OPERATING COSTS per day (cells AO18 - AQ21) are given numbers based on averaging the estimates of boat owners and operators. Range names with format OPCii were provided for this section.

EXAMPLE: OPC11 (cell AO18) = OPerating Costs for fleet 1 in season 1

	AN	AO	AP	AQ
15		AVERAGE (PER DAY)		
16		OPERATING COSTS [OPCii]		
17		Holiday	Summer	Winter
18	FLEET 1	250	200	225
19	FLEET 2	200	150	175
20	FLEET 3	250	200	225
21	FLEET 4	225	175	200

The AREA COST RATIO section (cells AS14 - AT20) adjusts for the variation in expenses involved with different fishing areas. More distant regions incur greater costs in hauling extra supplies to keep fish fresh and support the crew. Range names provided for the values in AT18 to AT21 have the format CRAi (in brackets).

EXAMPLE: CRA1 (cell AT18) = Cost Ratio for Area 1

	AR	AS	AT
15		AREA COST	
16		RATIO [CRAi]	
17			
18		AREA 1 =	1.09
19		AREA 2 =	1.30
20		AREA 3 =	1.37
21		AREA 4 =	1.53

The ratios are computed by dividing the Overall Annual Average Operating Days value (cell R22) by the difference between this overall value (cell R22) and the average Running days (provided in cells AD12 to AG12) for the area indicated.

	AS	AT
15	AREA COST	
16	RATIO [CRAi]	
17		
18	AREA 1 =	+R22/(R22-AD12)
19	AREA 2 =	+R22/(R22-AE12)
20	AREA 3 =	+R22/(R22-AF12)
21	AREA 4 =	+R22/(R22-AG12)

The last level of the Operating Environment Section contains ACTUAL FISHING DAYS per Trip per Season in cells G25 - I28. These numbers are the fishing days assigned by the LP83 program using information from the BASEBTM input spreadsheet. Since LP83 will try to utilize all available fishing days, the values in this section should be close to, or the same as, those in the section above (calculated Total Potential Fishing Days). The equations for these numbers are derived by adding all of the solution values (assigned fishing days) under each E variable included within a fleet/season (E#--#) category and dividing this sum by the number of boats fishing in that Fleet type (K variable value). Equations for Column G from Item C2 are shown below.

	F	G	H	I
23		ACTUAL FISHING DAYS (PER BOAT)		
24		Holiday	Summer	Winter
25	FLEET 1	37.8	84.2	89.7
26	FLEET 2	30.0	67.3	62.1
27	FLEET 3	37.8	84.2	89.7
28	FLEET 4	32.6	74.0	70.2

	G
	Holiday
25	(G35+J35+M35+P35+S35+V35+Y35+AB35+AE35+AH35+AK35+AN35)/EL35
26	(AQ35+AT35+AW35+AZ35+BC35+BF35+BI35+BL35+BO35)/EM35
27	(BR35+BU35+BX35+CA35+CD35+CG35+CJ35+CM35+CP35+CS35+CV35+CY35)/EN35
28	(DB35+DE35+DH35+DK35+DN35+DQ35+DT35+DW35+DZ35+EC35+EF35+EI35)/EO35

C. Data Section

This section delineates the linear programming problem's competing activities or decision variables (fishing situations and Fleet sizes) and all of the parameters needed for the LP83 package to make its evaluation about each variable. The parameter values represent the amount for each variable per fishing day. They could also be calculated on an operating day or an annualized basis.

Row 33 presents a list of all the problem's activity variables. It is a requirement of the LP83 package and has the range name 83VARIABLE (cells G33 through EO33).

	E	F	G	H	I	J	K	L
32								
33		VARIABLE LIST->	E1111	E1112	E1113	E1121	E1122	E1123

Since there are four vessel types, three species groups, four areas, and three seasons, the potential number of E variables for this model is 4X3X4X3 = 144. However, Fleet 2 does not have the capability to fish in area 4, so combinations with these characteristics (9) have been excluded leaving 135 E variables in the final list. [If no such natural exclusion exists in a problem, it may be necessary to artificially restrict the number of variables so that the model does not exceed the computer's memory capacity.]

In addition to the E variables, there are four K variables (cells EL33-EO33) representing the number of boats actively fishing in each Fleet category.

	EK	EL	EM	EN	EO
33	E4343	K1---	K2---	K3---	K4---

Row 35 has been set aside for the solution values (fishing days assigned to each E variable and number of boats included per Fleet type under each K variable) to be returned from the LP83 package after a run. This item could go elsewhere in the spreadsheet but has been placed here for convenience in reviewing the results of each program's run. It has been given the LP83 package range name of 83VA. In addition to the variable values, one cell (EP35) has been included to hold the net fleetwide profit sum.

	AG	AH	AI	EK	EL	EM	EN	EO	EP
33	E1313	E1321	E1322	E4343	K1---	K2---	K3---	K4---	NET PROFIT
34	----------	----------	----------	----------	----------	----------	----------	----------	----------
35	538.397626		505.052192		6	3	7.5	4	4778096.76

The parameter section begins in row 36 and extends through row 39. Daily catch rate (q) in row 36 is the average pounds of fish caught for a given fishing situation (E variable) per fishing day. It was input directly for the baseline spreadsheet. However, in subsequent versions, these values were calculated from a formula and the new numbers were brought into the spreadsheet as a group under a range name from an outside file.

	D	E	F	G	H	I
32		LP83 DATA SECTION (Fishing Day basis)				
33			VARIABLE LIST->	E1111	E1112	E1113
34		** ECONOMIC PARAMETERS		----------	----------	----------
35		** SOLUTION VALUES				
36		* DAILY CATCH RATE (q)		0	0	0
37		* FISH PRICE (p)		0.00	0.00	0.00
38		* DAILY OPERATING COST (c)		272	217	244
39		* ANNUAL FIXED COST/VESSEL		0	0	0

The fish price (p) in row 37 was also input directly after averaging values for each species group from the records in the 1987 bottomfish market survey. Changes for (p) values made in subsequent spreadsheets have been incorporated by using the external file's range name for the new price calculations.

The daily operating cost (c) in row 38 is the product of the fleet/season Average Operating Cost per Day (range name OPCii in AO17-AQ20) by the appropriate Area Cost factor (range name CRAi in cells AT17-AT20) for each variable. These ranges are defined in the Operating Environment Section.

	E	F	G
32	LP83 DATA SECTION (Fishing Day basis)		
33		VARIABLE LIST->	E1111
34	** ECONOMIC PARAMETERS		--
35	** SOLUTION VALUES		
36	* DAILY CATCH RATE (q)		0
37	* FISH PRICE (p)		0
38	* DAILY OPERATING COST (c)		+$OPC1H*$CRA1
39	* ANNUAL FIXED COST/VESSEL		0

Annual fixed costs per vessel (row 39) are an average value for each fleet type based on personal interviews with boat owners. For the bottomfish models in this report, the annual fixed cost has not been distributed by fishing day and appears as one sum at the end of the row under the appropriate K variable. The effect is that a full year's fixed costs are incorporated for any vessel included in the solution when LP83 evaluates the aggregate demand for fishing days, even if the vessel does not fish for the full year. [The seven previously mentioned submodels of the general Hawaii LP fishery model were being designed to address this issue more specifically. However, testing of these submodels remains to be finished.]

	EK	EL	EM	EN	EO
33	E4343	K1---	K2---	K3---	K4---
34	------------	------------	------------	------------	------------
35		6	3	7.5	4
36	112				
37	2.70				
38	305				
39	0	75000	60000	75000	50000

D. <u>Objective</u> <u>Section</u>

The objective function (goal) is a required component of the problem definition. For the bottomfish model it is to maximize fleetwide profit (row 41). Values representing the net revenue (profit or loss) of each fishing situation (E variable) or Fleet type (K variable) appear in row 42. These values are calculated by subtracting the daily operating costs (row 38) and annual fixed costs (row 39) from total revenue [the product of the catch rate (row 36) and fish price (row 37)] for each variable. [An equation example is shown below under column G.] The resulting number is the profit/loss "cost" margin associated with each variable when it is analyzed by the LP83 program. This row has the LP83 program range name of 83COST (cells G42-EO42).

D	E	F	G	H	I
33		VARIABLE LIST->	E1111	E1112	E1113
34	** ECONOMIC PARAMETERS		----------	----------	----------
35	** SOLUTION VALUES				
36	* DAILY CATCH RATE (q)		0	0	0
37	* FISH PRICE (p)		0.00	0.00	0.00
38	* DAILY OPERATING COST (c)		272	217	244
39	* ANNUAL FIXED COST/VESSEL		0	0	0
40	*				
41	*OBJECTIVE FUNCTION* - MAX FLEETWIDE PROFIT *******				
42			-272	-217	-244
			[(G36*G37)-(G38+G39)]		

E. Bounds Section

This section is required by the LP83 software program. It defines the range that solution values may have for each variable. Since the solution values for E variables will be returned in number of fishing days allocated to that situation, the smallest number of days (lower bound) will be 0. These lower limits appear in row 46 and have a range name of 83LOWER.

Upper bounds are determined by a formula based on the number of boats in the fleet type of an E variable. Range names for the appropriate maximum boats are multiplied by a fishing day factor (row 49) and this product is multiplied by the variable's estimated Potential Trips (range names PTii in cells AK9-AM12). The range name for this row (48) is 83UPPER and represents the maximum number of fishing days that can be allocated to a given fishing combination (E variable). [A formula example appears under the G column below.]

D	E	F	G	H	I
33		VARIABLE LIST->	E1111	E1112	E1113
44	** BOUNDS ****************		Effort Level Bounds (Based on Ca		
45		Fishing Days			
46	* LOWER BOUNDS		0	0	0
47					
48	* UPPER BOUNDS		595	1326	1413
			[+$FLT1*G49*$PT1H]		

The lower limits for the K variables are set as the minimum number of boats in that Fleet type (range name FLT0i). Upper limits reflect the maximum number of boats in a given Fleet (range name FLTi).

	EL	EM	EN	EO
33	K1---	K2---	K3---	K4---
46	+$FLT01	+$FLT02	+$FLT03	+$FLT04
47				
48	+$FLT1	+$FLT2	+$FLT3	+$FLT4
46	3	1.5	7.5	2
47				
48	6	3	15	4

Row 49 contains the number of fishing days per trip for each E variable. These values are derived by multiplying the Average Fishing Days (range name FDii in cells Z17-Z20) by the dividend of the Average Fleet Running Days (range names ARDFi in cells AH8-AH11) and the Running Days by Area per Trip (range names RDiAi in cells AD8-AG11). The resulting fishing days per trip value (shown in brackets under the equation below) accounts for the difference in travel time to each area.

D	E	F	G
33		VARIABLE LIST->	E1111
49	Fishing Days by Fleet,Area,Season		(FD1H*(ARDF1/RD1A1))
			[37]

F. Constraints Section

This section delineates the various inequalities that exist among the components of the problem. Constraints under Species limits (Q-##-) indicate the E variables that contribute to the demand on that specific resource. Where present, the value under each E variable (rows 52-60) represents the daily catch rate for that fishing combination given in row 36.

D	E	F	G	H	I	J	K	L
33		VARIABLE LIST->	E1111	E1112	E1113	E1121	E1122	E1123
36	* DAILY CATCH RATE (q)		0	0	0	0	0	47
50	** CONSTRAINTS ***************							
51								
52	* Q LIMITS	Q-11-	0	0	0			
53		Q-12-				0	0	47
54		Q-13-						
55		Q-14-						
56		Q-21-						
57		Q-22-						
58		Q-23-						
59		Q-24-						
60		Q-3--						

The total poundage (maximum sustainable yield) of Species 1 and 2 in each of the four areas and Species 3 (over all areas) that can be caught by all fishing combinations per year appears in column EQ (shown below).

	F	EN	EO	EP	EQ
52	Q-11-			<=	94000
53	Q-12-			<=	76200
54	Q-13-			<=	94400
55	Q-14-			<=	192400
56	Q-21-			<=	62750
57	Q-22-			<=	49800
58	Q-23-			<=	61600
59	Q-24-			<=	125600
60	Q-3--			<=	11000000

Ralston estimates total sustainable yield for all bottomfish in the NWHI as 600,000 pounds per year [Ref. 9, p. 3]. This figure has been divided between the model's two bottomfish species categories by averaging landings percentages in recent years. Under this procedure, Species 1 (opakapaka and onaga) receives 363,000 pounds (about 60%) while Species 2 (all other bottomfish) is assigned 237,000 pounds (around 40%).

Since the above total poundage covers only the NWHI region, the species amounts are subdivided and distributed among the three NWHI areas (2,3,4) for each bottomfish Species (1 and 2). Due to the difference in size of each area, the allowable Species poundages are allocated according to the following percentages.

Area 2 (Mau) -- 21%
Area 3 (Lower Hoomalu) -- 26%
Area 4 (Upper Hoomalu) -- 53%

Thus, the annual poundage limit for Species 1 in Area 2 [Q-12-] is 21% times 363,000 = 76,200 pounds. The other Species limits for areas 2, 3, and 4 are calculated in the same manner.

Within Area 1 (Main Hawaiian Islands), the maximum sustainable yield for all bottomfish is estimated to be 627,000 pounds [Ref. 9, p. 3]. The same Species percentages (listed above) apply -- 60% or 376,000 pounds are allocated to Species 1 (opakapaka and onaga) while 40% or 251,000 pounds go to Species 2 (all other bottomfish). Since there are many other (smaller) boats that catch bottomfish in this area, an estimate of 25% of these Species amounts has been attributed to vessels covered under the Bottomfish Model (BASEBTM). The annual percentage of Species 1 in Area 1 [Q-11-] is 376,000 times 25% = 94,000 pounds, and for Species 2 [Q-21-] -- 251,000 times 25% = 62,750 pounds.

The amount of pelagics (Species 3) available is set at 11 million pounds which is the highest landing (excluding skipjack tuna) reported recently throughout Hawaii [Ref. 10, p. 3]. This is not a sustainable yield limit (which may not be estimatable on a localized basis), but serves as a realistic upper bound for local harvest of pelagic species under the conditions of this model.

The E limits in rows 61 through 72 indicate with a 1 whether an E variable should be included with the set defined by the row label (such as E1--1 meaning fleet 1 fishing for any species in any area in season 1).

D	E	F	G	H	I	J	K	L
33		VARIABLE LIST->	E1111	E1112	E1113	E1121	E1122	E1123
61	* E LIMITS	E1--1	1			1		
62		E1--2		1			1	
63		E1--3			1			1
64		E2--1						
65		E2--2						
66		E2--3						
67		E3--1						
68		E3--2						
69		E3--3						
70		E4--1						
71		E4--2						
72		E4--3						

The constraint values for the K variables at the end of each row are the Total Potential Fishing Days per Fleet/Season (range names FiSi) available for the aggregate demand for fishing days within that row. This means that the total days fished by all vessels in a given Fleet (i) during a given season (m) do not exceed the limits assigned under the K variables for that Fleet and Season combination. These values have been set to negative numbers so that when all possible fishing days are used up, the right hand side (RHS) under column EQ will show 0 fishing days remaining.

		EL	EM	EN	EO	EP	EQ
61	E1--1	-38				<=	0
62	E1--2	-84				<=	0
63	E1--3	-90				<=	0
64	E2--1		-30			<=	0
65	E2--2		-67			<=	0
66	E2--3		-62			<=	0
67	E3--1			-38		<=	0
68	E3--2			-84		<=	0
69	E3--3			-90		<=	0
70	E4--1				-33	<=	0
71	E4--2				-74	<=	0
72	E4--3				-70	<=	0

VII. NWHI BOTTOMFISH LINEAR PROGRAMMING MODEL RESULTS

A. Running LP83 with the NWHI Model

LP83 runs interactively from a simple command line on the computer. The command allows a number of options in reporting results. A detailed description of the command line with some of its options is presented in Appendix A. However, the LP83 software could not be considered "user friendly," and use of the accompanying manual is required.

EXAMPLE: LP83 BASEBTM.WKS output C:PBASE maximize YES costanalysis YES marginanalysis YES

B. Report Description

Once the command is given to begin a run, LP83 uses the data spreadsheet (BASEBTM) for its required input and, when finished with the analysis, returns the solution values to the same spreadsheet (row 35, range name 83VA). A report giving more details about these solution values is also generated. [See Appendix C Item C4 for a sample report.]

The first part of the report (Item C4) lists the E variables (83VARIABLE) with their associated profit/loss factors (83COST). A negative cost number means this fishing situation would lose money while a positive number indicates a potential profit. Costs associated with the K variables are the annual fixed cost per boat for that fleet type.

```
(83VARIABLE)
(83COST)
   Objective: MAXIMIZED Variables:   139
     -271.6022 E1111                     97.0538 E1332
     -217.2817 E1112                    -21.5395 E1333
     -244.4419 E1113                 2,022.8809 E1341
     -324.1139 E1121                    14.6167 E1342
```

The second section shows each E variable with its lower and upper bounds. These values represent the fewest (left number) and most (right number) fishing days that could be assigned to the given E variable. Bounds associated with each K variable indicate the minimum (left) and maximum (right) number of boats in that fleet category.

```
0.0000 <- E1111 <-   594.6067
0.0000 <- E1112 <- 1,325.7620
0.0000 <- E1113 <- 1,413.2938
```

```
3.0000 <- K1--- <-  6.0000
1.5000 <- K2--- <-  3.0000
7.5000 <- K3--- <- 15.0000
2.0000 <- K4--- <-  4.0000
```

Part 3 groups the variables affected by each species poundage limit (Q value) and fishing days per fleet/season limit (E value). In the Q value groups, the number preceding each variable is the catch rate (q) for that fishing situation. The maximum annual poundage allowed to be caught for the given species appears at the end of the grouping. Within the E groups, each variable counts as one unit toward the total elements in the grouping. The negative value to the left of the K variable indicates the maximum number of available fishing days per boat NOT used up for that fleet/season. Zero is the number to the right of the K variable and it represents the upper limit value when all fishing days have been used.

```
Row: Q-14-    Elements:   9
      322.0000 E1141
      537.0000 E1142
      315.0000 E1143
        0.0000 E3141
      447.0000 E3142
      454.0000 E3143
      663.0000 E4141
      717.0000 E4142
      774.0000 E4143 <-192400
```

```
Row: E2--3    Elements:  10
        1.0000 E2113
        1.0000 E2123
        1.0000 E2133
        1.0000 E2213
        1.0000 E2223
        1.0000 E2233
        1.0000 E2313
        1.0000 E2323
        1.0000 E2333
      -62.0690 K2--- <- 0.00
```

Following Part 3 are some program statistics and a statement as to whether this run produced a unique set of solution values (no other allocation of fishing days would give the same or better fleetwide profit), or whether there are possible alternate solutions (other fishing day allocations may produce the same fleetwide profit). This model has substantial computer memory requirements, as indicated by the run-time statistics.

```
Statistics-
  LP83 Version 5.00
  Machine memory:  640K bytes.
  Pagable memory:  411K bytes.
  Variables:       139
  Constraints:      21

  21 LE,   0 EQ,   0 GE.
Non-zero LP elements:  282
Disk Space:     0K bytes.
Page Space:    23K bytes.
Capacity: 15.1% used.
Estimated Time: 00:01:43

          Iter   33
          Solution Time:  00:00:03
          U n i q u e   S o l u t i o n
```

Section 4 begins with the value of the maximized goal. For the bottomfish spreadsheet, it represents the maximum fleetwide net profit that could be earned if each fishing situation (E variable) used all of the fishing days (under Activities) allocated to it by the LP83 program. The profit or loss potential per variable is also given (under Cost). The LP program assigns fishing days to variables that are favored by some limitation or constraint and are also most economical (greatest revenue after expenses).

SOLUTION (Maximized): 4778096.761 NWHI Bottomfish Model - Baseline Version

Variable	Activity	Cost	Variable	Activity	Cost
E1111	0.0000	-271.6022	E1112	0.0000	-217.2817
E1113	0.0000	-244.4419	E1121	0.0000	-324.1139
E1313	538.3976	3,116.1181	E1321	0.0000	-324.1139
E1322	505.0522	306.2089	E1323	0.0000	1,951.1575
E1331	0.0000	-317.7227	E1332	0.0000	97.0538

Each K variable demonstrates the number of boats included in producing the solution values under the Activity column. The negative Cost value associated with the K variable is the annual fixed cost per boat in that Fleet category.

E4343	0.0000	-2.7833	K1---	6.0000	-75000.0000
K2---	3.0000	-60000.0000	K3---	7.5000	-75000.0000

LP tries to reduce the outlay for annual fixed costs by keeping the number of vessels per fleet in the solution to a minimum. This approach increases overall (Fleetwide) profit by using the most fishing time available with the fewest boats. If the vessels in a given Fleet category cannot cover their fixed costs or show a net profit with any fishing strategy, then that Fleet group will not be assigned any fishing days (unless forced into the solution with a minimum boat requirement).

Part 5 is a table listing each fish species (Q-##-) and fleet/season (E#--#) group under the Constraint column. The Activity column for the Q constraints records all of this species (per area) poundage that was caught, while the RHS (right hand side) column shows the total poundage available (annual sustainable species by area limit). Activity for each fleet/season (E) variable indicates either that all of the available fishing days were used up or no fishing days were used (0), or that some fishing days were used with some remaining (a negative number). The RHS column represents the upper limit (0) when all available fishing days are used.

CONSTRAINTS: NWHI Bottomfish Model - Baseline Version

Constraint	Activity	RHS	Constraint	Activity	RHS
Q-11-	94,000.0000	<94,000.0000	Q-12-	76,200.0000	<76,200.0000
Q-13-	94,400.0000	<94,400.0000	Q-14-	192400.0000	<192400.0000
Q-21-	0.0000	<62,750.0000	Q-22-	19,125.0000	<49,800.0000
Q-23-	61,600.0000	<61,600.0000	Q-24-	125600.0000	<125600.0000
Q-3--	2275504.590	<11000000.00	E1--1	0.0000	< 0.0000
E1--2	0.0000	< 0.0000	E1--3	0.0000	< 0.0000

If a "cost analysis" has been requested, its report would appear in Part 6. Results are presented in a table with each variable enclosed in a box along with its upper and lower stable cost ranges and reduced cost values.

COST ANALYSIS: NWHI Bottomfish Model - Baseline Version

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	527.5186	<------	Upper	306.2089	<------
E1111	-271.6022		E1112	-217.2817	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		799.1207	Reduced Cost		523.4906
Upper	3,116.1181	<------	Upper	527.5186	<------
E1113	-244.4419		E1121	-324.1139	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		3,360.5600	Reduced Cost		851.6324

The "upper" number equals the profit per fishing day that would be needed by the fishing situation which the variable represents before a change in the current solution (allocation of fishing days) would take place. The number to the right of the variable is its current profit or loss potential. The "lower" number represents the profit value to which this fishing situation could fall before causing a change in the current solution. If either "upper" or "lower" equals "unbounded," then movement of the variable's profit/loss value in that direction would not change the current allocation of fishing days. This typically occurs when some resource limit has been reached making profitability irrelevant.

The Variable to Change column shows which variable or constraint (if any) is affecting the "upper" and "lower" range value. "Reduced Cost" is the amount by which the variable's profitability (revenue minus costs) must be enhanced in order to achieve the "upper" range value which would enable this variable to participate in producing the net Fleetwide profit. When "reduced cost" refers to the lower limit, it indicates the potential decrease in profitability that could occur before causing a change in fishing day allocations (i.e., the variable would "fall out of" or be eliminated from participation in the solution). Variables that are already in the solution (fishing days are assigned to them) have a "reduced cost" of zero. If fishing days are forced to be assigned to an unprofitable fishing situation (E variable) by a minimum boat requirement, then the "reduced cost" also indicates the dollar amount that would be lost from the net Fleetwide profit for each fishing day so assigned. [Ref. 2, p. 17]

The analysis indicates the degree of stability of the model's solution values (number and location of assigned fishing days). Those values that are close to an "upper" or "lower" limit most likely would change if any input parameter fluctuates, even to a small degree. Therefore, such borderline fishing day allocations cannot be used with confidence, and the input data for these fishing situations may need more detailed evaluation.

The "margin analysis" report usually follows the cost analysis when specified in the command line. This table contains each constraint whose resource is fully utilized, and thereby limiting the solution, in a separate box. At the top of the species box (Q-##-) is listed the maximum annual species poundage allowed to be caught in the designated area. The number to the right of "increases objective by" is the amount (in dollars) each additional pound of fish in this species (by area) group would contribute to the net profit. Conversely, it also indicates the amount by which the current net Fleetwide profit would be decreased if the fish poundage for the species/area group is reduced by one "unit" (sum of all variables in the group). This amount is the "shadow price" and will remain valid within the specified upper and lower "new limit" ranges for annual poundage. "New optimum" indicates what the net profit would be if the respective upper or lower poundage limits were reached. "Forced to limit" presents the variable or constraint that affects this value. [Ref. 2, p. 17-21]

MARGINAL ANALYSIS: NWHI Bottomfish Model - Baseline Version

Constraint at limit	Value	Constraint at limit	Value
Q-11- <	94,000.0000	Q-12- <	76,200.0000
Increases objective ... by	3.0268	Increases objective ... by	2.1492
Upper Limit.		Upper Limit.	
New limit ..	125768.8073	New limit ..	145465.4554
New optimum ...	4874255.936	New optimum ...	4926958.835
Forced to limit	E4242	Forced to limit	E3131
Lower Limit.		Lower Limit.	
New limit ..	85,988.2253	New limit ..	26,114.9488
New optimum ...	4753846.382	New optimum ...	4670456.314
Forced to limit	E3243	Forced to limit	E3133

In the fleet/species (E#--#) part of the table, the shadow price indicates this variable group's contribution in dollars per allocated fishing day to the net Fleetwide profit. The "new limit" value under "Upper Limit" represents the number of additional fishing days that could be added for which this shadow price would apply. With these additional days, the maximum possible fishing days available for that Fleet/Season group would be reached making the shadow price equal to zero. If these "new limit" fishing days are added, then the net Fleetwide profit would be increased to the amount listed as "new optimum." Conversely, if the number of fishing days available to this group were reduced below the "new limit" under "Lower Limit," there would be a drop in the net Fleetwide profit to the amount shown as "new optimum" under "Lower Limit." [Ref. 2, p. 22-23]

Constraint	Value	Constraint	Value
E1--1 <	0.0000	E1--2 <	0.0000
Increases objective ...		Increases objective ...	
by	527.5186	by	306.2089
Upper Limit.		Upper Limit.	
New limit ..	12.4557	New limit ..	25.2526
New optimum ...	4784667.351	New optimum ...	4785829.336
Forced to limit	E3243	Forced to limit	E1322
Lower Limit.		Lower Limit.	
New limit ..	-77.8652	New limit ..	-505.0522
New optimum ...	4737021.438	New optimum ...	4623445.278
Forced to limit	E1241	Forced to limit	E1322

C. Updated Spreadsheet (Solution)

The updated BASEBTM spreadsheet (Item C1 in Appendix C) demonstrates the solution values of variable activities that are returned by the LP83 program. These activity numbers (appearing in row 35) represent the fishing days assigned to the E variable in the same column (row 33) and the number of boats included in each Fleet category (K variable). The last number returned from the analysis (cell EP35) is the net fleetwide profit which represents this LP problem's maximized profit solution. The only other parts of the spreadsheet that change are the values under Actual Fishing Days per Trip (G24 to I27) and Actual Trips per Boat (AK17 to AM20) whose equations depend on these assigned fishing days.

	AG	AH	AI	EK	EL	EM	EN	EO	EP
33	E1313	E1321	E1322	E4343	K1---	K2---	K3---	K4---	NET PROFIT
34	----------	----------	----------	----------	----------	----------	----------	----------	----------
35	538.397626		505.052192		6	3	7.5	4	4778096.76

EXAMPLE: Under variable E1313, 538 fishing days have been assigned to Fleet 1 (large, multipurpose vessels) targeting Species 3 (pelagics) in Area 1 (Main Hawaiian Islands) during Season 3 (Winter).

For convenience, the entire data section area (E33 to EP39) of the updated spreadsheet can be VALUED (to change all equations to their numeric value) and TRANSPOSED (to make a vertical table of the variables and all their associated values) into a blank region of the spreadsheet. This transposed table can then be EXTRACTED to its own Lotus file, edited, and printed [see item C5 of Appendix C].

D. Interpretation of BASEBTM Model Results

This section describes the results of the BASEBTM model. It must be stressed that these are hypothetical results which test the model's basic functions, but do not reflect on actual conditions in the Bottomfish fishery, nor do they imply potential management actions. Further use of the model in the context of the Council's process for proposing and evaluating potential fishery management measures is required before the model's results can be applied.

The report from BASEBTM shows that all of the vessels (maximum number) in Fleets 1, 2, and 4, but only the minimum number in Fleet 3 (tuna longliners and trollers), are included in this model's solution [Item C4 of Appendix C -- end of Lower and Upper Bounds section]. Since the Q limits for Species 2 (other bottomfish) in areas 1 and 2, and for Species 3 (pelagics) were not used up [see previous example of the Constraints Table], the income (catch rate times price) from these fishing situations is probably not sufficient to offset all vessel costs and, thereby, enable the excluded boats in Fleet 3 to fish for underutilized Species 2 or 3.

Total catch for the boats that fished included the maximum poundage allowed (457,000 pounds) for Species 1 (opakapaka and onaga) and 69 percent (206,325 pounds) of Species 2 (other bottomfish). Around 20 percent of the allowable limit for pelagics (Species 3) equaling 2.2 million pounds was also harvested. The landings of Species 1 are restricted by the natural resource constraint (annual poundage limit) while landings of Species 2 and 3 are limited by vessel costs (net profitability).

The combined number of fishing days assigned in the solution is 4043 (sum of all Solution Activity values for the E variables -- Item C4, Solution Table). On average, therefore, each vessel would have 197 fishing days per year. Based on the fixed and operating costs estimated for this model, and the other operating parameters (including product price and species catch rates) fleetwide profits are $4.7 million which amounts to an average of $233,000 per vessel. Approximate contributions to this net revenue from each species group are as follows.

Species 1 (opakapaka & onaga)	-- 22.7%	or	$1,084,628
Species 2 (other bottomfish)	-- 5.3%	or	$ 253,239
Species 3 (pelagics)	-- 72.0%	or	$3,440,230

These figures are derived from the report's Solution Table. For each variable containing a given species component, the Activity value (assigned number of fishing days) is multiplied by its Cost value (Fleet revenue per fishing day) to give the revenue generated by that fishing situation. These numbers are then summed producing the total revenue for a given fish species. Since the fixed costs are not subtracted from the Cost values in the table, the total Fleetwide revenue at this point equals the sum of these Species total revenue figures ($6.17 million). This sum is then used as the dividend in calculating the percent contribution of each Species group. The accompanying dollar estimates result from multiplying each Species percentage <u>times</u> the final total fleetwide revenue given at the beginning of the table -- $4.77 million. This value is obtained by calculating each fleet's annual fixed costs (number of participating boats <u>times</u> the fixed cost per boat), summing these fleet annual costs ($1.39 million), and subtracting this sum from the table's total revenue ($6.17 million).

The manner in which fishing days are distributed among the variables (fishing situations) indicates the most profitable utilization of the NWHI Bottomfish fleet's efforts given BASEBTM input data. Of course, fishing vessel operators may have other reasons for allocating their fishing effort, such as minimizing risk and uncertainty. Location of a market landing is recorded as the farthest point of travel on a trip and does not necessarily mean that all the fish harvested came from this area. No catch by specific area data are available. Although fishing effort may not be restricted to the area designated, costs are calculated as if it were for accounting purposes.

Fleet 1 (consisting of 6 large, multipurpose boats) fishes for pelagics around the Main Hawaiian Islands in Winter and in the Mau area during the Summer season. For the Holiday season, Fleet 1 would be fishing farther away in the Upper Hoomalu area. Target species are pelagics with a few days devoted to harvesting Species 2 (other bottomfish). Most of the Fleet 1 annual fishing effort would be spent on pelagics (94%) with only 6% on other bottomfish (Species 2) and 0% for Species 1 (opakapaka & onaga). Given this model's input data, the result suggests that large, multipurpose vessels cannot profitably fish for bottomfish in the NWHI.

Fleet 2 (three medium, multipurpose vessels) would fish during the Holiday season in the Mau area principally for Species 2 (other bottomfish) while catching some pelagics (Species 3). For the remainder of the year, only pelagics are taken. Most of the Summer harvest would be from the Mau area while all of the Winter catch is in the Main Hawaiian Islands. Annually, Fleet 2 spends 84% of its time catching pelagics, 16% on Species 2 (other bottomfish), and no effort for Species 1 (opakapaka & onaga). Again, fishing for bottomfish is not a profitable operation for this type of vessel under this model's conditions.

Fleet 3 (using only 7.5 of its 15 available tuna longliners or trollers) devotes approximately 58 percent of its Holiday season to harvesting Species 1 (opakapaka and onaga) and 42 percent to Species 2 (other bottomfish). Fishing effort is divided between the Lower Hoomalu (70%) and Mau (30%) areas. Pelagics (Species 3) from Lower Hoomalu make up all of the Summer catch. During the Winter, two-thirds of the fishing effort would occur in Upper Hoomalu with 95% of the time devoted to catching Species 1 (opakapaka & onaga) and 5% to Species 2 (other bottomfish). The remaining third of fishing effort would be spent in the Lower Hoomalu region harvesting pelagics (60%) and Species 1 (40%). Overall, Fleet 3 uses 48% of its annual fishing time for pelagics, 43% for Species 1 (opakapaka & onaga), and 9% for Species 2 (other bottomfish).

Fleet 4 (four motor-sailers) catches pelagics around the Main Hawaiian Islands during the Holiday season. Species 1 (opakapaka & onaga), also from the Main Hawaiian Islands, and some Species 2 (other bottomfish) from Upper Hoomalu are taken in Summer. In Winter the fishing effort is spent primarily on pelagics in the Mau area with just a few days given to Species 1 in Lower Hoomalu. Fleet 4 allocates 57% of its annual fishing time to pelagics, 33% to Species 1 (opakapaka & onaga), and 10% for Species 2 (other bottomfish).

<u>It is important to reiterate that these results are still hypothetical.</u> They serve to identify potential weaknesses in the basic parameter input values and potential impacts of alternative specifications of the model. Some of these implications are described in the following section.

VIII. FOLLOW-UP PERMUTATIONS

A. <u>Distributed Versus Raw Data</u>

Due to lack of raw data for many fishing situations in the baseline NWHI bottomfish model (BASEBTM), the original catch rate and price per pound rows were replaced in a modified spreadsheet labeled <u>BTM1</u> (see Item D1 of Appendix D) with values generated from averaged fleet/species and area/season tables. The generated catch rates distribute the original (q) data more diffusely among the E variables so that they all have some (q) value. This results in many variables being assigned smaller (q) rates instead of a few variables having large (q) rates and several variables with no (q) values.

VARIABLE	BASEBTM		BTM1	
	(q)	(p)	(q)	(p)
E1111	0	0.00	180	3.66
E1112	0	0.00	230	2.35
E1113	0	0.00	241	2.88
E1131	431	3.32	109	4.40
E1132	405	3.50	92	3.56
E1133	295	2.96	110	3.09

Rows with generated q and p values [file QPTABLE -- see Appendix D, item D2] were VALUED and given RANGE names in the QPTABLE spreadsheet. The range names were then incorporated into the appropriate rows in a copy of the BASEBTM spreadsheet to create the modified BTM1 version. LP83 runs made with this spreadsheet should enable a better evaluation of the revenue potential for each fishing situation. If a pattern had been found in the raw data as to distribution of catch rates and fish prices, then the dBASE program originally developed by Wesley Higuchi, formerly of the Honolulu Laboratory, for changing these parameters could have been used here. The dBASE program assumes there is some consistent relationship among some of the variables with regard to a parameter. For example, the catch rate (q) for Species 1 in season 3 is consistently twice what it is in seasons 1 and 2.

Results from a run with the BTM1 spreadsheet show a very different pattern of vessel utilization. [See report, Item D3 of Appendix D.] Now Fleets 1 and 2 have only the minimum number of boats fishing while Fleet 3 has all available boats actively employed. Fleet 4 remains the same as in the BASEBTM run with the maximum number of boats fishing.

<u>Boats Participating</u>

BASEBTM		BTM1	
K1---	6	K1---	3
K2---	3	K2---	1.5
K3---	7.5	K3---	15
K4---	4	K4---	4

Since many of the species per area annual (Q) limits were not used up, the distributed catch rates and/or prices per pound for these fishing situations were to low to offset Fleet 1 and Fleet 2 vessel costs so that idle boats could be fishing for the underutilized species. Under these circumstances, LP83 calculates that it would not be profitable to send more Fleet 1 and Fleet 2 boats out fishing. Actually, it may not be profitable under the BTM1 regime to allocate any fishing days to Fleet 1 or Fleet 2. Fishing days may have been assigned due to this model's having a minimum number of boats in each Fleet requirement. [See the BTM5 trial below for results of a run with no minimum boat requirements.]

The net fleetwide profit has fallen to less than half that of the baseline version -- $2.0 million for BTM1 versus $4.7 million under the BASEBTM regime. Due to the fully occupied Fleet 3, the total number of fishing days allocated has increased from 4043 to 4757. Each boat on average fishes a few more days per year, but makes much less in revenue -- $88,657 (BTM1) compared to $233,000 (BASEBTM). The distributed data produces generally lower catch rates and prices per pound, so a much greater effort is required to make the same revenue.

Species 3, with its high annual allowable catch (Q), has the most fishing days (>70%) assigned to it and, hence, it contributes the greatest dollar value to the net profit. Both bottomfish categories (Species 1 and 2) are more limited as to annual pounds allowed to be caught.

Major changes have occurred as to when, where, and what species are harvested by each Fleet. For ease in comparing results from the two models, their variables, parameters and solution values are presented in Item C5 (BASEBTM) and Item D4 (BTM1).

Fleet 1 (now only 3 large, multipurpose boats) spends its time fishing in the Upper Hoomalu and Main Hawaiian Island areas with no effort in the Mau region. Fishing days are devoted mainly to Species 2 (85%) with Species 1 (opakapaka and onaga) given 15% of the time. No pelagics are taken [in BASEBTM these were 94% of its effort]. This represents a more realistic view of Fleet 1's activity than model BASEBTM.

BASEBTM

VARIABLE	FISH DAYS
E1111	(spaces mean
E1112	no fishing
E1113	days assigned)
E1121	
E1122	
E1123	
E1131	
E1132	
E1133	
E1141	
E1142	
E1143	
E1211	
E1212	
E1213	
E1221	
E1222	
E1223	
E1231	
E1232	
E1233	
E1241	78
E1242	
E1243	
E1311	
E1312	
E1313	538
E1321	
E1322	505
E1323	
E1331	
E1332	
E1333	
E1341	149
E1342	
E1343	

BTM1

VARIABLE	FISH DAYS
E1111	
E1112	
E1113	99
E1121	
E1122	
E1123	
E1131	
E1132	
E1133	
E1141	1
E1142	
E1143	
E1211	
E1212	
E1213	170
E1221	
E1222	
E1223	
E1231	
E1232	
E1233	
E1241	112
E1242	253
E1243	
E1311	
E1312	
E1313	
E1321	
E1322	
E1323	
E1331	
E1332	
E1333	
E1341	
E1342	
E1343	

Fleet 2 (one full-time and one part-time vessel) fishes only around the Main Hawaiian Islands and does not make any trips to the Mau area as was the case in BASEBTM. It harvests pelagics exclusively, having abandoned even the small effort for Species 2 (other bottomfish) made in BASEBTM. This result is consistent with recent price trends, but it does not adequately reflect Fleet 2's bottomfishing activity.

BASEBTM		BTM1	
VARIABLE	FISH DAYS	VARIABLE	FISH DAYS
E2221	75	E2221	
E2222		E2222	
E2223		E2223	
E2231		E2231	
E2232		E2232	
E2233		E2233	
E2311		E2311	45
E2312	34	E2312	101
E2313	186	E2313	93
E2321	15	E2321	
E2322	168	E2322	
E2323		E2323	
E2331		E2331	
E2332		E2332	
E2333		E2333	

Fleet 3 (15 tuna longline and troller vessels) no longer spends any time in the Mau or Lower Hoomalu regions but, instead, concentrates 62% of its fishing effort around the Main Hawaiian Islands (where there was no effort in BASEBTM). The remainder (38%) of its fishing days are devoted to the Upper Hoomalu area (similar to BASEBTM). The catch is now solely pelagics --a result that mirrors the current real world situation. Under BASEBTM, all three species groups were taken.

BASEBTM

VARIABLE	FISH DAYS
E3111	
E3112	
E3113	
E3121	86
E3122	
E3123	
E3131	78
E3132	
E3133	92
E3141	
E3142	
E3143	424
E3211	
E3212	
E3213	
E3221	
E3222	
E3223	
E3231	119
E3232	
E3233	
E3241	
E3242	
E3243	22
E3311	
E3312	
E3313	
E3321	
E3322	
E3323	
E3331	
E3332	631
E3333	136
E3341	
E3342	
E3343	

BTM1

VARIABLE	FISH DAYS
E3111	
E3112	
E3113	
E3121	
E3122	
E3123	
E3131	
E3132	
E3133	
E3141	
E3142	
E3143	
E3211	
E3212	
E3213	
E3221	
E3222	
E3223	
E3231	
E3232	
E3233	
E3241	
E3242	
E3243	
E3311	195
E3312	434
E3313	1346
E3321	
E3322	
E3323	
E3331	
E3332	
E3333	
E3341	372
E3342	829
E3343	

Fleet 4 (four motor-sailers) scatters its fishing effort over all areas as it did in BASEBTM, but the amount of time per area differs. Its catch is also less varied. Species 1 (opakapaka & onaga) is taken exclusively in contrast to BASEBTM where Species 3 (pelagics) comprised about 57% of the catch, Species 1 around 33%, and Species 2 (other bottomfish) about 10%.

BASEBTM

VARIABLE	FISH DAYS
E4111	
E4112	221
E4113	
E4121	
E4122	
E4123	
E4131	
E4132	
E4133	10
E4141	
E4142	
E4143	
E4211	
E4212	
E4213	
E4221	
E4222	
E4223	
E4231	
E4232	
E4233	
E4241	
E4242	75
E4243	
E4311	130
E4312	
E4313	
E4321	
E4322	
E4323	271
E4331	
E4332	
E4333	
E4341	
E4342	
E4343	

BTM1

VARIABLE	FISH DAYS
E4111	17
E4112	
E4113	132
E4121	
E4122	96
E4123	
E4131	25
E4132	
E4133	
E4141	88
E4142	200
E4143	149
E4211	
E4212	
E4213	
E4221	
E4222	
E4223	
E4231	
E4232	
E4233	
E4241	
E4242	
E4243	
E4311	
E4312	
E4313	
E4321	
E4322	
E4323	
E4331	
E4332	
E4333	
E4341	
E4342	
E4343	

For the model as a whole, annually, fewer fishing days were allocated to Species 1 (opakapaka and onaga) with more effort going to Species 2 (other bottomfish) and Species 3 (pelagics) than in BASEBTM.

Percent of Fishing Days

BASEBTM	BTM1
Species 1 - 23%	Species 1 - 17%
Species 2 - 9%	Species 2 - 11%
Species 3 - 68%	Species 3 - 72%

With regard to the annual poundage available for each species, BTM1 does not utilize any species to its capacity whereas BASEBTM reaches the limit for Species 1 (opakapaka and onaga).

Species Poundage Utilization

BASEBTM	BTM1
Species 1 - 100%	Species 1 - 68%
Species 2 - 69%	Species 2 - 63%
Species 3 - 20%	Species 3 - 14%

B. Other Modifications

Various changes can be made in parameter values to determine the effect a given parameter has on the LP outcome. Several examples are described below. For convenience, Table 1 showing all the pertinent values to be compared concludes this report. The BTM1 model with distributed q and p values is used as the spreadsheet to be modified. Each version is given a separate BTM# label. Due to the bulkiness of output from each run, these reports are not included with this submission. They are on file and can be provided, if a hard copy is desired.

BTM2. This model differs from BTM1 in that the maximum number of boats in each Fleet (1-4) reflects the greater number of bottomfish licenses issued to fishermen in 1987 instead of only the number of active boats (those making market landings). The minimum number of boats to be included remains at one-half of the maximum.

Fleet Size Bounds

BTM1	BTM2
3.0000 <= K1--- <= 6.0000	5.0000 <= K1---<= 10.0000
1.5000 <= K2--- <= 3.0000	7.0000 <= K2---<= 14.0000
7.5000 <= K3--- <=15.0000	5.5000 <= K3---<= 11.0000
2.0000 <= K4--- <= 4.0000	2.0000 <= K4---<= 4.0000

This regimen requires more boats in Fleets 1 and 2 to be included in the solution. Since the income/cost ratio is very low for these vessels, the fleetwide net profit drops considerably to $1.4 million (from $2.0 million in BTM1). With more boats sharing a smaller net profit, individual vessel revenue declines accordingly ($51,748 versus $88,657 of BTM1).

Boats Participating

BTM1		BTM2	
K1---	3	K1---	5
K2---	1.5	K2---	7
K3---	15	K3---	11
K4---	4	K4---	4

Species per area utilization is similar in BTM1 and BTM2. Species 1 (opakapaka and onaga) and Species 2 (other bottomfish) in areas 1 (Main Hawaiian Islands) and 4 (Upper Hoomalu) are fully utilized. Species 2 is not caught in areas 2 (Mau) and 3 (Lower Hoomalu) in either model. The annual harvest of Species 1 in areas 2 and 3 increased, while that of Species 3 (pelagics) decreased under model BTM2.

Annual Harvest

SPECIES & AREA	BTM1	BTM2
Species 1, area 2	20,500 lbs	66,400 lbs
Species 1, area 3	5,400 lbs	9,300 lbs
Species 3	1.6 M lbs	1.3 M lbs

Even though the total number of fishing days assigned has increased (from 4757 to 5209), each boat has 9 fewer days. Fleet 1 now divides its time about equally between Species 1 (opakapaka and onaga) and Species 2 (other bottomfish) in contrast to BTM1.

Percent of Allocated Fishing Days

SPECIES	BTM1	BTM2
1	15%	47%
2	85%	53%

Fleets 2 and 3 have their fishing days distributed to the same areas and species as in BTM1, but with more days per area for Fleet 2 and fewer for Fleet 3. Fleet 4 shifted its effort from Upper Hoomalu and Main Hawaiian Islands to Lower Hoomalu and Mau.

Overall, more fishing days were allocated to Species 1 (opakapaka and onaga) and less to Species 3 (pelagics) than in BTM1.

Percent of Fishing Days

BTM1	BTM2
Species 1 - 17%	Species 1 - 23%
Species 2 - 11%	Species 2 - 11%
Species 3 - 72%	Species 3 - 66%

The annual poundage available is, again, not fully utilized for any species. However, more of Species 1 was harvested while less of Species 3 was taken, reflecting the shift in fishing effort. The catch for Species 2 (other bottomfish) is the same in both models.

Species Poundage Utilization

BTM1	BTM2
Species 1 - 68%	Species 1 - 79%
Species 2 - 63%	Species 2 - 63%
Species 3 - 14%	Species 3 - 12%

BTM3. The catch rate (q) of BTM1 was doubled across the variable range. Net profit increases over three fold (from $2.0 million to $6.5 million) as does the average boat revenue.

However, the maximum number of boats is still not employed in every fleet. Fleet 1 operates with its minimum number; Fleet 2 now uses its maximum; and Fleets 3 and 4 continue at maximum.

Boats Participating

BTM1		BTM3	
K1---	3	K1---	3
K2---	1.5	K2---	3
K3---	15	K3---	15
K4---	4	K4---	4

Species 1 (opakapaka and onaga) is now fully utilized in all areas. Harvest of Species 2 (other bottomfish) has increased to 96% of it annual poundage limit while Species 3 (pelagics) has expanded to 30% of capacity (up from 14% in BTM1).

Species Poundage Utilization

BTM1	BTM3
Species 1 - 68%	Species 1 - 100%
Species 2 - 63%	Species 2 - 96%
Species 3 - 14%	Species 3 - 30%

There are 1.5 more boats participating in the fishery with an average allocation of 200 fishing days per boat. Total allocation for all Fleets is 4995 fishing days.

Fleet 1 (large, multipurpose) continues catching Species 2 (other bottomfish), but now targets Species 3 (pelagics) instead of Species 1 (opakapaka and onaga) as in BTM1. It devotes about 70% of its effort to Species 2 and the remainder to Species 3. Fleet 2 still fishes only for pelagics, but since twice as many vessels are participating, the fishing day allocation has doubled. There is no change in fishing effort for Fleet 3. Fleet 4 continues to harvest Species 1 exclusively, but shifts its effort from the Upper Hoomalu and Main Hawaiian Islands to Lower Hoomalu and Mau regions.

Annually, fewer fishing days were allocated to Species 1 (opakapaka and onaga) and Species 2 (other bottomfish) with more going to Species 3 (pelagics) than in BTM1.

Percent of Fishing Days

BTM1	BTM3
Species 1 - 17%	Species 1 - 14%
Species 2 - 11%	Species 2 - 9%
Species 3 - 72%	Species 3 - 77%

BTM4. In this model, the fish price per pound was raised by 50% for all the variables. The result was similar to BTM3 in that more boats in Fleet 2 were able to participate due to improvement in their vessel income/cost ratios. Fleet 1, however, still employs only a fraction above its minimum vessel requirement. Fleets 3 and 4 continue at maximum activity.

Boats Participating

BTM1		BTM4	
K1---	3	K1---	3.1
K2---	1.5	K2---	3
K3---	15	K3---	15
K4---	4	K4---	4

As would be expected, the net profit and average boat revenue have increased (more than double those of BTM1), but are not as high as BTM3.

Net Fleetwide Profit

BTM1	BTM3	BTM4
$2.0 Million	$6.5 Million	$4.6 Million

Species 1 (opakapaka and onaga) in area 3 (Lower Hoomalu) is utilized to an greater extent indicating that some of the additional boats were able to make a profit with this catch. A little more (1%) of Species 3 (pelagics) is also taken. Additional boats cause a rise in the total number of fishing days allocated. Doubling the catch rate had a greater impact on improving fishery profits than increasing fish prices by 50%.

Species targeting remains the same as in BTM1. However, Fleet 1 spends more time fishing in the Upper Hoomalu area. Fleet 2 has twice as many boats fishing in the same pattern so its fishing day allocation has doubled. There is no change in Fleet 3. Fleet 4 does more fishing around the Main Hawaiian Islands during the winter instead of in Upper Hoomalu as in BTM1.

Fishing days were allocated in about the same proportion among the three species groups in both models.

Percent of Fishing Days

BTM1	BTM4
Species 1 - 17%	Species 1 - 16%
Species 2 - 11%	Species 2 - 11%
Species 3 - 72%	Species 3 - 73%

The annual poundage taken of each species was also almost the same.

Species Poundage Utilization

BTM1	BTM4
Species 1 - 68%	Species 1 - 69%
Species 2 - 63%	Species 2 - 63%
Species 3 - 14%	Species 3 - 15%

BTM5. To determine the extent to which minimum boat per fleet requirements influence the solution outcome, all boat minimums were reduced to 0 in BTM5. The result was that all of the boats in Fleet 1 (large, multipurpose) and Fleet 2 (medium, multipurpose) were excluded from the problem's solution. No change took place in Fleets 3 and 4. Total number of boats is 4.5 less than under BTM1 and there are, consequently, fewer fleetwide fishing days assigned.

Boats Participating

BTM1		BTM5	
K1---	3	K1---	0
K2---	1.5	K2---	0
K3---	15	K3---	15
K4---	4	K4---	4

Interestingly, the net profit rose from $2.0 million to $2.2 million. Individual vessel revenues increased as well [$115,000 versus $88,600 in BTM1] due to fewer boats sharing the available fishing days and the greater fleetwide profit.

Targeting of Species 1 (opakapaka & onaga) and 3 (pelagics) stayed the same, but that of Species 2 (other bottomfish) fell to 0. Apparently, the distributed catch rates (q) and/or prices per pound (p) for this species group are not profitable for anyone. Under these conditions, forcing more boats into the solution with minimum vessel requirements (as is done in BTM1 and BTM2) adversely affects the combined fleetwide revenue. Utilization of Species 1 dropped a bit while that of Species 3 remained the same.

Species Poundage Utilization

BTM1	BTM5
Species 1 - 68%	Species 1 - 66%
Species 2 - 63%	Species 2 - 0%
Species 3 - 14%	Species 3 - 14%

Fishing days removed from Species 2 (11%) were allocated mainly to Species 3.

Percent of Fishing Days

BTM1	BTM5
Species 1 - 17%	Species 1 - 18%
Species 2 - 11%	Species 2 - 0%
Species 3 - 72%	Species 3 - 82%

BTM6. In an attempt to have the maximum number of boats employed without forcing them into the solution, both the catch rate (q) and the price per pound (p) have been increased in this model to enhance the income/cost ratio for all fishing situations. Catch rates have been doubled and fish prices raised by 50 percent. The result brought all available boats into the solution.

Boats Participating

BTM1		BTM6	
K1---	3	K1---	6
K2---	1.5	K2---	3
K3---	15	K3---	15
K4---	4	K4---	4

With maximum vessel activity, the total number of fishing days assigned was 5443. Net Fleetwide Profit ($11.5 million) and the corresponding average vessel revenue ($411,500) were the greatest of any trial. Both bottomfish categories (Species 1 and 2) were fully utilized, and the pelagic (Species 3) harvest reached its highest level at 31% of the annual limit.

Species Poundage Utilization

BTM1	BTM6
Species 1 - 68%	Species 1 - 100%
Species 2 - 63%	Species 2 - 100%
Species 3 - 14%	Species 3 - 31%

Species targeting changed for Fleet 1, but remained the same for Fleets 2, 3 and 4. Fleet 1 (large, multipurpose) now spends even less time (3%) on Species 1 (opakapaka & onaga) and divides its remaining fishing days about equally between Species 2 (other bottomfish) and Species 3 (pelagics). While still catching only Species 1, Fleet 4 (motor-sailers) spends more time fishing in the Lower Hoomalu and Mau area rather than Upper Hoomalu and Main Hawaiian Island regions as in BTM1.

The change in fishing strategy by Fleet 1 is reflected in the overall fishery effort. Time no longer spent harvesting Species 1 is distributed instead to Species 2 and Species 3.

Percent of Fishing Days

BTM1	BTM6
Species 1 - 17%	Species 1 - 10%
Species 2 - 11%	Species 2 - 12%
Species 3 - 72%	Species 3 - 78%

BTM7. This run was to see what the greatest impact would be if all available boats insisted on being allocated fishing time. The minimum boat number was set to equal the maximum boat number. Such a situation might arise if for social, cultural or political reasons, no one could be excluded from fishing.

Boats Participating

BTM1		BTM7	
K1---	3	K1---	6
K2---	1.5	K2---	3
K3---	15	K3---	15
K4---	4	K4---	4

The results showed an expected decline in net fleetwide profit and average vessel revenue. Net profit under BTM1 was $2.0 million while that of BTM7 equaled $1.88 million.

More of Species 1 (opakapaka and onaga) was harvested in areas 2 (Mau) and 3 (Lower Hoomalu) causing a significant increase in annual yield. Utilization of Species 2 (other bottomfish) remained the same, but that of Species 3 (pelagics) increased a little to 15% of the allowable poundage.

Species Poundage Utilization

BTM1	BTM7
Species 1 - 68%	Species 1 - 84%
Species 2 - 63%	Species 2 - 63%
Species 3 - 14%	Species 3 - 15%

While Fleet 1 continued to catch the same fish species as it did under BTM1, it devoted more time to Species 1 in all areas except Lower Hoomalu and in all seasons. Fleet 4 shifted some effort to Mau and Lower Hoomalu from the Main Hawaiian Island and Upper Hoomalu areas.

The proportion of fishing days diverted from Species 2 and Species 3 has been assigned to Species 1.

Percent of Fishing Days

BTM1	BTM7
Species 1 - 17%	Species 1 - 25%
Species 2 - 11%	Species 2 - 10%
Species 3 - 72%	Species 3 - 65%

BTM8. In this model, twice as many boats are made available to the fishery, but the problem differs from a similar version (BTM2) in that the minimum vessel numbers are held at the BTM1 level and not forced to increase with the new maximums.

Fleet Size Bounds

BTM1	BTM8
3.0000 <= K1--- <= 6.00	3.0000 <= K1--- <= 12.00
1.5000 <= K2--- <= 3.00	1.5000 <= K2--- <= 6.00
7.5000 <= K3--- <= 15.00	7.5000 <= K3--- <= 30.00
2.0000 <= K4--- <= 4.00	2.0000 <= K4--- <= 8.00

The resulting solution indicates that there is room in the fishery to profitably accommodate quite a few additional boats in Fleet 3, and to some extent in Fleet 4 also.

Boats Participating

BTM1		BTM8	
K1---	3	K1---	3
K2---	1.5	K2---	1.5
K3---	15	K3---	30
K4---	4	K4---	7.9

Fleet 3 (tuna longliners and trollers) continues to fish exclusively for pelagics (Species 3), which with their high annual limit remain underutilized. As long as the allowable poundage for Species 3 remains at this level, it would, theoretically, be possible to include even more boats in Fleet 3. However, the LP model can not take into account what would happen to the price per pound for pelagics if that many fish were landed.

Species 1 (opakapaka and onaga) is used to its maximum limit by Fleet 4 (motor-sailers) which fishes exclusively for this species in both models. Increased utilization of Species 1 is due to more boats participating in Fleet 4. It appears that Fleet 4 has a higher income/cost ratio with regard to Species 1 than does Fleet 1 (large, multipurpose) which now does not catch any Species 1. When more motor-sailers are available, LP83 preferentially allocates fishing days for Species 1 to these vessels. In BTM1 with fewer Fleet 4 boats, the excess Species 1 poundage was given to Fleet 1. Since a minimum number (3) of less profitable Fleet 1 boats must be included in this solution, they draw Species 2 assignments as in BTM1, but, in addition, now have some Species 3 (pelagics) allocation instead of Species 1.

Species Poundage Utilization

BTM1	BTM8
Species 1 - 68%	Species 1 - 100%
Species 2 - 63%	Species 2 - 63%
Species 3 - 14%	Species 3 - 29%

Due to all of the additional boats in the fishery, the total number of fishing days allocated was 8616. Net Fleetwide Profit amounted to $3.8 million compared to $2.0 million for BTM1.

Although the amount of Species 1 taken has been maximized and Species 2 utilization increased a little, the large harvest of Species 3 (more than twice that of BTM1) causes the relative amount of time spent on this species (pelagics) to increase.

Percent of Fishing Days

BTM1	BTM8
Species 1 - 17%	Species 1 - 16%
Species 2 - 11%	Species 2 - 6%
Species 3 - 72%	Species 3 - 78%

C. Summary

This report has shown how the NWHI bottomfish model operates and what some of its preliminary results might be. In light of these results, an examination of the basic parameter values is warranted at this point. Once fine-tuning of the parameters is complete, the model will be ready for use as an aid to fishery management decisions.

TABLE 1. SUMMARY OF LP MODEL VARIATION RESULTS

VERSION	CHANGE	BOATS IN SOLUTION	PROFIT NET (M)	BOAT REV AVG (K)	Q LBS USED (%)	TOTAL FISH DAYS	AVG FISH DAYS/BOAT	FISH DAYS /SPEC. (%)	FLEET q /SPEC. (%)
BASEBTM	NONE	FLT 1= 6 [6]	$4.7	$233	SP 1= 100%	4043	197	SP 1= 23%	FLEET 1
	(RAW DATA)	FLT 2= 3 [3]			SP 2= 69%			SP 2= 9%	SP 1 = 0%
		FLT 3= 7.5 [15]			SP 3= 20%			SP 3= 68%	SP 2 = 6%
		FLT 4= 4 [4]							SP 3= 94%
		TOTAL= 20.5 [28]							FLEET 2
									SP 1 = 0%
									SP 2= 16%
									SP 3= 84%
									FLEET 3
									SP 1= 43%
									SP 2= 9%
									SP 3= 48%
									FLEET 4
									SP 1= 33%
									SP 2 =10%
									SP 3= 57%
BTM1	q and p	FLT 1= 3 [6]	$2.0	$88.6	SP 1= 68%	4757	202	SP 1= 17%	FLEET 1
	distribute	FLT 2= 1.5 [3]			SP 2= 63%			SP 2= 11%	SP 1 = 15%
		FLT 3= 15 [15]			SP 3= 14%			SP 3= 72%	SP 2 = 85%
		FLT 4= 4 [4]							SP 3 = 0%
		TOTAL= 23.5 [28]							FLEET 2
									SP 1 = 0%
									SP 2 = 0%
									SP 3= 100%
									FLEET 3
									SP 1 = 0%
									SP 2 = 0%
									SP 3= 100%
									FLEET 4
									SP 1= 100%
									SP 2 = 0%
									SP 3 = 0%

TABLE 1. (CONTINUED)

VERSION	CHANGE	BOATS IN SOLUTION	PROFIT NET (M)	BOAT REV AVG (K)	Q LBS USED (%)	TOTAL FISH DAYS	AVG FISH DAYS/BOAT	FISH DAYS /SPEC. (%)	FLEET q /SPEC. (%)
BTM2	maximum	FLT 1= 5 [10]	$1.4	$51.7	SP 1= 79%	5209	193	SP 1= 23%	FLEET 1
	boats= all	FLT 2= 7 [14]			SP 2= 63%			SP 2= 11%	SP 1 = 47%
	licenses	FLT 3= 11 [11]			SP 3= 12%			SP 3= 66%	SP 2 = 53%
	issued	FLT 4= 4 [4]							SP 3 = 0%
		TOTAL= 27 [39]							FLEET 2
									SP 1 = 0%
									SP 2 = 0%
									SP 3= 100%
									FLEET 3
									SP 1 = 0%
									SP 2 = 0%
									SP 3= 100%
									FLEET 4
									SP 1= 100%
									SP 2 = 0%
									SP 3 = 0%
BTM3	q of BTM1	FLT 1= 3 [6]	$6.5	$263	SP 1= 100%	4995	200	SP 1 =14%	FLEET 1
	times 2	FLT 2= 3 [3]			SP 2= 96%			SP 2 = 9%	SP 1 = 0%
		FLT 3= 15 [15]			SP 3= 30%			SP 3= 77%	SP 2 = 70%
		FLT 4= 4 [4]							SP 3 = 30%
		TOTAL= 25 [28]							FLEET 2
									SP 1 = 0%
									SP 2 = 0%
									SP 3= 100%
									FLEET 3
									SP 1 = 0%
									SP 2 = 0%
									SP 3= 100%
									FLEET 4
									SP 1= 100%
									SP 2 = 0%
									SP 3= 0%

TABLE 1. (CONTINUED)

VERSION	CHANGE	BOATS IN SOLUTION	PROFIT NET (M)	BOAT REV AVG (K)	Q LBS USED (%)	TOTAL FISH DAYS	AVG FISH DAYS/BOAT	FISH DAYS /SPEC. (%)	FLEET q /SPEC. (%)
BTM4	p of BTM1 times 1.5	FLT 1= 3.1 [6] FLT 2= 3 [3] FLT 3= 15 [15] FLT 4= 4 [4] TOTAL= 25 [28]	$4.6	$184	SP 1= 69% SP 2= 63% SP 3= 15%	5021	201	SP 1= 16% SP 2= 11% SP 3= 73%	FLEET 1 SP 1 = 15% SP 2 = 85% SP 3 = 0% FLEET 2 SP 1 = 0% SP 2 = 0% SP 3= 100% FLEET 3 SP 1 = 0% SP 2 = 0% SP 3= 100% FLEET 4 SP 1= 100% SP 2 = 0% SP 3 = 0%
BTM5	minimum boats of BTM1 = 0	FLT 1= 0 [6] FLT 2= 0 [3] FLT 3= 15 [15] FLT 4= 4 [4] TOTAL= 19 [28]	$2.2	$115	SP 1= 66% SP 2= 0% SP 3= 14%	3883	204	SP 1= 18% SP 2= 0% SP 3= 82%	FLEET 1 SP 1 = 0% SP 2 = 0% SP 3 = 0% FLEET 2 SP 1 = 0% SP 2 = 0% SP 3 = 0% FLEET 3 SP 1 = 0% SP 2 = 0% SP 3= 100% FLEET 4 SP 1= 100% SP 2 = 0% SP 3 = 0%

TABLE 1. (CONTINUED)

VERSION	CHANGE	BOATS IN SOLUTION	PROFIT NET (M)	BOAT REV AVG (K)	Q LBS USED (%)	TOTAL FISH DAYS	AVG FISH DAYS/BOAT	FISH DAYS /SPEC. (%)	FLEET q /SPEC. (%)
BTM6	using BTM1 q X 2 and p X 1.5	FLT 1= 6 [6] FLT 2= 3 [3] FLT 3= 15 [15] FLT 4= 4 [4] TOTAL= 28 [28]	$11.5	$411	SP 1= 100% SP 2= 100% SP 3= 31%	5443	194	SP 1= 10% SP 2= 12% SP 3= 78%	FLEET 1 SP 1 = 3% SP 2 = 49% SP 3 = 48% FLEET 2 SP 1 = 0% SP 2 = 0% SP 3= 100% FLEET 3 SP 1 = 0% SP 2 = 0% SP 3= 100% FLEET 4 SP 1= 100% SP 2 = 0% SP 3= 0%
BTM7	using BTM1 minimum boats = maximum	FLT 1= 6 [6] FLT 2= 3 [3] FLT 3= 15 [15] FLT 4= 4 [4] TOTAL= 28 [28]	$1.9	$67.3	SP 1= 84% SP 2= 63% SP 3= 15%	5631	201	SP 1= 25% SP 2= 10% SP 3= 65%	FLEET 1 SP 1 = 57% SP 2 = 43% SP 3 = 0% FLEET 2 SP 1 = 0% SP 2 = 0% SP 3= 100% FLEET 3 SP 1 = 0% SP 2 = 0% SP 3= 100% FLEET 4 SP 1= 100% SP 2 = 0% SP 3 = 0%

TABLE 1. (CONTINUED)

VERSION	CHANGE	BOATS IN SOLUTION	PROFIT NET (M)	BOAT REV AVG (K)	Q LBS USED (%)	TOTAL FISH DAYS	AVG FISH DAYS/BOAT	FISH DAYS /SPEC. (%)	FLEET q /SPEC. (%)
BTM8	using BTM1	FLT 1= 3 [12]	$3.8	$90.8	SP 1= 100%	8616	203	SP 1= 16%	FLEET 1
	maximum	FLT 2= 1.5 [6]			SP 2= 63%			SP 2= 6%	SP 1 = 0%
	boats =	FLT 3= 30 [30]			SP 3= 29%			SP 3= 78%	SP 2= 84%
	times 2,	FLT 4= 7.9 [8]							SP 3 = 16%
	minimum	TOTAL= 42.5 [28]							FLEET 2
	boats =								SP 1 = 0%
	times 1/4								SP 2 = 0%
									SP 3= 100%
									FLEET 3
									SP 1 = 0%
									SP 2 = 0%
									SP 3= 100%
									FLEET 4
									SP 1 =100%
									SP 2 = 0%
									SP 3 = 0%

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APPENDIX A

APPENDIX A: LP83 MANUAL SUMMARY

Appendix A is a summary of the main points presented in the LP83 manual that accompanies the software package [Ref. 4].

I. INTRODUCTION

The LP83 package requires that a problem be stated in a specific manner in terms of the solution objective and attendant constraints. Care must be taken in stating the problem so that no solution value can be negative. The objective function of the problem describes either the total "profit" to be obtained from or the total "cost" to be controlled by the set of variable activities. It is defined for LP83 in economic (dollar) terms, but units of time or capacity could also be used. The goal is to maximize or minimize (whichever is appropriate) the value of the objective function subject to its constraints. Constraints present either limitations on resources or maximum/minimum requirements that must be satisfied.

A Lotus 1-2-3 spreadsheet can be used for the problem description and input as long as there are fewer than 254 variables. The LP83 program looks for its specific range names for the title, variables, pricing coefficients, bounds, constraints and reduced costs to solve a problem. Users must provide the appropriate cell address for each range name.

II. REQUIRED SECTIONS AND THEIR ORDER

A. TITLE. This section is not required but is very useful in identifying each problem and its modified versions. A title statement (preceded by asterisks) is followed by the problem's title. [Note: Lines beginning with * are comment lines and thus ignored by the LP program.] The range name 83TITLE is set aside in the package for the title.

B. OBJECTIVE. The objective statement follows the Title section and has at least 2 input lines that are <u>required</u>. The first line is the variable list (given the range name 83VARIABLE), and the second required row is the pricing coefficient (or associated profit/loss cost) for each variable (given the range name 83COST).

83VARIABLE must be a single row (or single column range) with one variable name per cell. The variable name can be from 1-8 characters in length. There should be no blank cells or duplicate names in the this range as the number of variables is used to check for other specifications such as pricing coefficients, constraints, and reduced costs.

83COST must also be a single row (or single column range) with the same number of cells as 83VARIABLE. Each variable has a profit/loss value associated with it even if this value is zero.

C. BOUNDS. The Bounds section is not required, but, if used, must follow the Objective Section. It delineates constraints which limit the permissible range of a variable. The presence of these constraints causes the highly efficient bounding algorithm to be employed. Two lines of input are needed, each of which must be a single row (or single column range) that is equal in number of cells to 83VARIABLE. The first line presents the smallest or least value that could be assigned to the corresponding variable and has the range name of 83LOWER. The second row sets the largest or greatest value possible for that same variable. The range name for the second row is 83UPPER.

D. CONSTRAINTS. This section is required and must follow the Bounds and/or Objective sections. It consists of one or more rows of input and is used to:

1. label the constraints on the problem's resources;
2. state the variable coefficients with regard to a given constraint;
3. define the type of constraint (<=, >=, =);
4. define the right hand side (RHS) value or resource limit for each constraint.

The first cell for each row in this section must specify a constraint label of no more than 8 characters followed by a colon (:). Cells to the right of the label relate to the variable in the same column (above) and, where appropriate, are filled with a non-zero technological coefficient (such as 1). Each row ends with a sign indicating the type of constraint [whether <= or => or =] being defined and this is immediately followed by the right hand side (RHS) value or total limit on that resource. Usually these limits are not precise. Either there is a maximum limit (which does not have to be utilized) or a minimum limit (which may be exceeded) within which a solution may be found. The LP program range name is 83CONSTRAINT and includes all cells to the left of the signs.

E. ACTIVITY. This section is optional and usually follows the Constraint section when present. However, it can be placed within the Objective section for easy reading of each variable's activity value. It may contain 1-4 lines of input that are returned from the LP program after a problem has been solved. The information that could be returned is:

1. the variable's activity value at solution - amount of the objective function or goal that is allocated to each variable (range name = 83VA);

2. the constraint's activity at solution - amount of each constrained resource used (range name = 83CA);

3. the variable's reduced cost (range name = 83VR);

4. the constraint's reduced cost (range name = 83CR).

III. HOW LP83 WORKS

In a graphical representation, an optimal solution to a linear programming problem is always a corner point of the feasible area or range of the solution. This is the basis for solving LP problems and the Simplex Method is programmed to find these corners. Mathematical rules instruct the computer how and when to shift corner points. At each step the computer moves closer to an optimal solution (if it exists). Additionally, the instructions are supposed to yield an optimum result in a finite number of steps (iterations). [Ref. 1, p. 17-18]

To initiate a run with the LP83 program, the following command line is given at the C> prompt.

```
C>LP83 BASEBTM.WKS OUTPUT C:PBT1 MAXIMIZE YES
```

<u>LP83</u> identifies the program source file. <u>BASEBTM.WKS</u> gives the name of the data file (spreadsheet) to use. <u>OUTPUT</u> requests that a report of the results be returned from the run. <u>C:PBT1</u> identifies the drive (C) and a name under which this report is to be filed. <u>MAXIMIZE</u> <u>YES</u> tells the program what to do with the objective or goal which is under range name 83COST (maximize it). If a cost analysis and/or margin analysis is desired, the term <u>COSTANALYSIS</u> <u>YES</u> and/or <u>MARGINANALYSIS</u> <u>YES</u> is added to the above line.

When finished, the LP83 program returns a report under the file name PBT1 (or whatever you designated) on drive C that can be read and edited with Word Star (or some other word processing package). The basic report states the activity of each variable for a maximum profit (if that is the goal) and gives the value of the maximized goal. Whatever additional analyses (cost/margin) that were requested appear at the end of the report.

The program has the flexibility to explore the effects of changes in the stated problem once an optimum solution for the original objective and attending constraints has been determined.

OPC	AO18..AQ20	
OPC1H	AO18	
OPC1S	AP18	
OPC1W	AQ18	
OPC2H	AO19	
OPC2S	AP19	
OPC2W	AQ19	) daily OPerating Cost for fleet #
OPC3H	AO20	) in season "L"
OPC3S	AP20	
OPC3W	AQ20	
OPC4H	AO21	
OPC4S	AP21	
OPC4W	AQ21	
SEAH	U7	
SEAS	V7	) calendar days per SEAson "L"
SEAW	W7	
PT1H	AK9	
PT1S	AL9	
PT1W	AM9	
PT2H	AK10	
PT2S	AL10	
PT2W	AM10	) Potential Trips for fleet # in season "L"
PT3H	AK11	
PT3S	AL11	
PT3W	AM11	
PT4H	AK12	
PT4S	AL12	
PT4W	AM12	
RD1A1	AD8	
RD1A2	AE8	
RD1A3	AF8	
RD1A4	AG8	
RD2A1	AD9	
RD2A2	AE9	) Running Days for fleet # to Area #
RD2A3	AF9	
RD3A1	AD10	
RD3A2	AE10	
RD3A3	AF10	
RD3A4	AG10	
RD4A1	AD11	
RD4A2	AE11	
RD4A3	AF11	
RD4A4	AG11	

RD1H	AE17	
RD1S	AF17	
RD1W	AG17	
RD2H	AE18	
RD2S	AF18	) average Running Days for fleet #
RD2W	AG18	) in season "L"
RD3H	AE19	
RD3S	AF19	
RD3W	AG19	
RD4H	AE20	
RD4S	AF20	
RD4W	AG20	
RDSH	AE22	
RDSS	AF22	) Running Day ratio for Season "L"
RDSW	AG22	
TD1H	U17	
TD1S	V17	
TD1W	W17	
TD2H	U18	
TD2S	V18	
TD2W	W18	) Turn-around Days for fleet # in season "L"
TD3H	U19	
TD3S	V19	
TD3W	W19	
TD4H	U20	
TD4S	V20	
TD4W	W20	

APPENDIX - ITEM C4: LP83 REPORT FROM BASELINE RUN

```
LP83 BASEBTM.WKS OUTPUT C:PBASE MAXIMIZE YES COSTANALYSIS YES
     MARGINANALYSIS YES
```

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1613 Chelsea Road, Suite 153
San Marino, California 91108 U.S.A.
(818) 284-4763
Licensed Solely To: National Marine Fisheries Services
Honolulu, Hawaii

(83TITLE)
Title: NWHI Bottomfish Model - Baseline Version

(83VARIABLE)
(83COST)

Objective: MAXIMIZED Variables: 139

-271.6022	E1111	97.0538	E1332
-217.2817	E1112	-21.5395	E1333
-244.4419	E1113	2,022.8809	E1341
-324.1139	E1121	14.6167	E1342
-259.2911	E1122	330.2888	E1343
-134.2525	E1123	201.0383	E2111
1,089.1873	E1131	-57.9313	E2112
1,144.1138	E1132	-110.7715	E2113
565.6405	E1133	-259.2911	E2121
751.9609	E1141	-194.4683	E2122
1,499.1367	E1142	-87.9497	E2123
693.0188	E1143	-273.3862	E2131
-271.6022	E1211	-205.0396	E2132
-217.2817	E1212	-239.2129	E2133
-244.4419	E1213	-110.0417	E2211
-324.1139	E1221	28.3987	E2212
-259.2911	E1222	-190.1215	E2213
25.0975	E1223	536.3089	E2221
474.2673	E1231	-145.4683	E2222
254.6138	E1232	138.5203	E2223
358.3005	E1233	-273.3862	E2231
1,452.4809	E1241	-205.0396	E2232
1,183.3167	E1242	-239.2129	E2233
811.6688	E1243	-58.0317	E2311
-271.6022	E1311	282.5987	E2312
-217.2817	E1312	1,501.8785	E2313
3,116.1181	E1313	109.3089	E2321
-324.1139	E1321	2,439.0217	E2322

306.2089 E1322
1,951.1575 E1323
-317.7227 E1331
-239.2129 E2333
-271.6022 E3111
-217.2817 E3112
-160.9819 E3113
2,585.2461 E3121
-259.2911 E3122
-291.7025 E3123
2,113.0673 E3131
-157.4662 E3132
1,019.0405 E3133
-381.4791 E3141
1,192.2667 E3142
1,400.0288 E3143
-271.6022 E3211
-217.2817 E3212
-203.6419 E3213
345.5361 E3221
-259.2911 E3222
-291.7025 E3223
883.5573 E3231
182.3238 E3232
205.6805 E3233
-381.4791 E3241
322.8667 E3242
673.9088 E3243
-271.6022 E3311
-217.2817 E3312
-190.2119 E3313
-190.0639 E3321
-259.2911 E3322
-291.7025 E3323
-268.6127 E3331
316.8138 E3332
139.9205 E3333
-381.4791 E3341
-237.9233 E3342
-42.0812 E3343
-244.4419 E4111
507.9803 E2323
-273.3862 E2331
-205.0396 E2332
1,382.3785 E4112
-217.2817 E4113
-291.7025 E4121
-226.8797 E4122
-259.2911 E4123
305.5205 E4131
-231.2129 E4132
2,270.4738 E4133
2,355.0788 E4141
1,934.1546 E4142
2,179.3567 E4143
-244.4419 E4211
-190.1215 E4212
-217.2817 E4213
-291.7025 E4221
-226.8797 E4222
-259.2911 E4223
-31.5595 E4231
-239.2129 E4232
-273.3862 E4233
840.7488 E4241
707.1246 E4242
705.8167 E4243
1,619.0981 E4311
-190.1215 E4312
-217.2817 E4313
1,462.6975 E4321
-226.8797 E4322
4,350.6289 E4323
-277.0495 E4331
-239.2129 E4332
-273.3862 E4333
-254.5012 E4341
-7.6554 E4342
-2.7833 E4343
-75000.0000 K1---
-60000.0000 K2---
-75000.0000 K3---
-50000.0000 K4---

(83LOWER)
(83UPPER)
Lower & Upper Bounds

0.0000 <= E1111 <= 594.6067
0.0000 <= E1112 <= 1,325.7620
0.0000 <= E1113 <= 1,413.2938
0.0000 <= E1121 <= 237.8427
0.0000 <= E1122 <= 530.3048
0.0000 <= E1123 <= 565.3175
0.0000 <= E1211 <= 594.6067
0.0000 <= E1212 <= 1,325.7620
0.0000 <= E1213 <= 1,413.2938
0.0000 <= E1221 <= 237.8427
0.0000 <= E1222 <= 530.3048
0.0000 <= E1223 <= 565.3175

0.0000	<=	E1131	<=	198.2022
0.0000	<=	E1132	<=	441.9207
0.0000	<=	E1133	<=	471.0979
0.0000	<=	E1141	<=	148.6517
0.0000	<=	E1142	<=	331.4405
0.0000	<=	E1143	<=	353.3234
0.0000	<=	E1311	<=	594.6067
0.0000	<=	E1312	<=	1,325.7620
0.0000	<=	E1313	<=	1,413.2938
0.0000	<=	E1321	<=	237.8427
0.0000	<=	E1322	<=	530.3048
0.0000	<=	E1323	<=	565.3175
0.0000	<=	E1331	<=	198.2022
0.0000	<=	E1332	<=	441.9207
0.0000	<=	E1333	<=	471.0979
0.0000	<=	E1341	<=	148.6517
0.0000	<=	E1342	<=	331.4405
0.0000	<=	E1343	<=	353.3234
0.0000	<=	E2111	<=	225.0000
0.0000	<=	E2112	<=	504.6729
0.0000	<=	E2113	<=	465.5172
0.0000	<=	E2121	<=	75.0000
0.0000	<=	E2122	<=	168.2243
0.0000	<=	E2123	<=	155.1724
0.0000	<=	E2131	<=	64.2857
0.0000	<=	E2132	<=	144.1923
0.0000	<=	E2133	<=	133.0049
0.0000	<=	E2211	<=	225.0000
0.0000	<=	E2212	<=	504.6729
0.0000	<=	E2213	<=	465.5172
0.0000	<=	E2221	<=	75.0000
0.0000	<=	E2222	<=	168.2243
0.0000	<=	E2223	<=	155.1724
0.0000	<=	E2231	<=	64.2857
0.0000	<=	E2232	<=	144.1923
0.0000	<=	E2233	<=	133.0049
0.0000	<=	E2311	<=	225.0000
0.0000	<=	E2312	<=	504.6729
0.0000	<=	E2313	<=	465.5172
0.0000	<=	E2321	<=	75.0000
0.0000	<=	E2322	<=	168.2243
0.0000	<=	E2323	<=	155.1724
0.0000	<=	E2331	<=	64.2857
0.0000	<=	E2332	<=	144.1923
0.0000	<=	E2333	<=	133.0049
0.0000	<=	E3111	<=	1,486.5169
0.0000	<=	E3112	<=	3,314.4050
0.0000	<=	E3113	<=	3,533.2344
0.0000	<=	E3121	<=	594.6067
0.0000	<=	E3122	<=	1,325.7620
0.0000	<=	E3123	<=	1,413.2938
0.0000	<=	E1231	<=	198.2022
0.0000	<=	E1232	<=	441.9207
0.0000	<=	E1233	<=	471.0979
0.0000	<=	E1241	<=	148.6517
0.0000	<=	E1242	<=	331.4405
0.0000	<=	E1243	<=	353.3234
0.0000	<=	E3221	<=	594.6067
0.0000	<=	E3222	<=	1,325.7620
0.0000	<=	E3223	<=	1,413.2938
0.0000	<=	E3231	<=	495.5056
0.0000	<=	E3232	<=	1,104.8017
0.0000	<=	E3233	<=	1,177.7448
0.0000	<=	E3241	<=	371.6292
0.0000	<=	E3242	<=	828.6013
0.0000	<=	E3243	<=	883.3086
0.0000	<=	E3311	<=	1,486.5169
0.0000	<=	E3312	<=	3,314.4050
0.0000	<=	E3313	<=	3,533.2344
0.0000	<=	E3321	<=	594.6067
0.0000	<=	E3322	<=	1,325.7620
0.0000	<=	E3323	<=	1,413.2938
0.0000	<=	E3331	<=	495.5056
0.0000	<=	E3332	<=	1,104.8017
0.0000	<=	E3333	<=	1,177.7448
0.0000	<=	E3341	<=	371.6292
0.0000	<=	E3342	<=	828.6013
0.0000	<=	E3343	<=	883.3086
0.0000	<=	E4111	<=	440.3883
0.0000	<=	E4112	<=	998.7523
0.0000	<=	E4113	<=	947.1926
0.0000	<=	E4121	<=	125.8252
0.0000	<=	E4122	<=	285.3578
0.0000	<=	E4123	<=	270.6265
0.0000	<=	E4131	<=	110.0971
0.0000	<=	E4132	<=	249.6881
0.0000	<=	E4133	<=	236.7981
0.0000	<=	E4141	<=	88.0777
0.0000	<=	E4142	<=	199.7505
0.0000	<=	E4143	<=	189.4385
0.0000	<=	E4211	<=	440.3883
0.0000	<=	E4212	<=	998.7523
0.0000	<=	E4213	<=	947.1926
0.0000	<=	E4221	<=	125.8252
0.0000	<=	E4222	<=	285.3578
0.0000	<=	E4223	<=	270.6265
0.0000	<=	E4231	<=	110.0971
0.0000	<=	E4232	<=	249.6881
0.0000	<=	E4233	<=	236.7981
0.0000	<=	E4241	<=	88.0777
0.0000	<=	E4242	<=	199.7505
0.0000	<=	E4243	<=	189.4385

0.0000	<=	E3131	<=	495.5056
0.0000	<=	E3132	<=	1,104.8017
0.0000	<=	E3133	<=	1,177.7448
0.0000	<=	E3141	<=	371.6292
0.0000	<=	E3142	<=	828.6013
0.0000	<=	E3143	<=	883.3086
0.0000	<=	E3211	<=	1,486.5169
0.0000	<=	E3212	<=	3,314.4050
0.0000	<=	E3213	<=	3,533.2344
3.0000	<=	K1---	<=	6.0000
1.5000	<=	K2---	<=	3.0000
7.5000	<=	K3---	<=	15.0000
2.0000	<=	K4---	<=	4.0000

0.0000	<=	E4311	<=	440.3883
0.0000	<=	E4312	<=	998.7523
0.0000	<=	E4313	<=	947.1926
0.0000	<=	E4321	<=	125.8252
0.0000	<=	E4322	<=	285.3578
0.0000	<=	E4323	<=	270.6265
0.0000	<=	E4331	<=	110.0971
0.0000	<=	E4332	<=	249.6881
0.0000	<=	E4333	<=	236.7981
0.0000	<=	E4341	<=	88.0777
0.0000	<=	E4342	<=	199.7505
0.0000	<=	E4343	<=	189.4385

(83CONSTRAINT)

Row: Q-11- Elements: 12

0.0000	E1111
0.0000	E1112
0.0000	E1113
83.0000	E2111
27.0000	E2112
23.0000	E2113
0.0000	E3111
0.0000	E3112
26.0000	E3113
0.0000	E4111
425.0000	E4112
0.0000	E4113 <=94,000.0000

Row: Q-12- Elements: 12

0.0000	E1121
0.0000	E1122
47.0000	E1123
0.0000	E2121
0.0000	E2122
33.0000	E2123
887.0000	E3121
0.0000	E3122
0.0000	E3123
0.0000	E4121
0.0000	E4122
0.0000	E4123 <=76,200.0000

Row: Q-13- Elements: 12

431.0000	E1131
405.0000	E1132
295.0000	E1133
0.0000	E2131
0.0000	E2132
0.0000	E2133
646.0000	E3131
21.0000	E3132
396.0000	E3133
117.0000	E4131
10.0000	E4132
746.0000	E4133 <=94,400.0000

Row: Q-14- Elements: 9

322.0000	E1141
537.0000	E1142
315.0000	E1143
0.0000	E3141
447.0000	E3142
454.0000	E3143
663.0000	E4141
717.0000	E4142
774.0000	E4143 <=192400.0000

Row: Q-21- Elements: 12

0.0000 E1211
0.0000 E1212
0.0000 E1213
28.0000 E2211
92.0000 E2212
0.0000 E2213
0.0000 E3211
0.0000 E3212
16.0000 E3213
0.0000 E4211
0.0000 E4212
0.0000 E4213 <=62,750.0000

Row: Q-22- Elements: 12

0.0000 E1221
0.0000 E1222
144.0000 E1223
255.0000 E2221
35.0000 E2222
145.0000 E2223
295.0000 E3221
0.0000 E3222
0.0000 E3223
0.0000 E4221
0.0000 E4222
0.0000 E4223 <=49,800.0000

Row: Q-23- Elements: 12

272.0000 E1231
300.0000 E1232
394.0000 E1233
0.0000 E2231
0.0000 E2232
0.0000 E2233
517.0000 E3231
199.0000 E3232
282.0000 E3233
120.0000 E4231
0.0000 E4232
0.0000 E4233 <=61,600.0000

Row: Q-24- Elements: 9

899.0000 E1241
1,145.0000 E1242
825.0000 E1243
0.0000 E3241
395.0000 E3242
519.0000 E3243
779.0000 E4241
594.0000 E4242
674.0000 E4243 <=125600.0000

Row: Q-3-- Elements: 45

0.0000 E1311
0.0000 E1312
1,412.0000 E1313
0.0000 E1321
377.0000 E1322
1,289.0000 E1323
7.0000 E1331
189.0000 E1332
126.0000 E1333
1,108.0000 E1341
164.0000 E1342
309.0000 E1343
35.0000 E2311
188.0000 E2312
705.0000 E2313
97.0000 E2321
1,009.0000 E2322
362.0000 E2323
0.0000 E2331
0.0000 E2332
0.0000 E2333
0.0000 E3311
0.0000 E3312
29.0000 E3313
35.0000 E3321
0.0000 E3322
0.0000 E3323
16.0000 E3331
130.0000 E3332
226.0000 E3333
0.0000 E3341
38.0000 E3342
125.0000 E3343
783.0000 E4311
0.0000 E4312
0.0000 E4313
1,020.0000 E4321
0.0000 E4322
2,352.0000 E4323
9.0000 E4331
0.0000 E4332
0.0000 E4333
21.0000 E4341
99.0000 E4342
112.0000 E4343<=11000000.00

```
Row: E1--1    Elements:  13
        1.0000 E1111
        1.0000 E1121
        1.0000 E1131
        1.0000 E1141
        1.0000 E1211
        1.0000 E1221
        1.0000 E1231
        1.0000 E1241
        1.0000 E1311
        1.0000 E1321
        1.0000 E1331
        1.0000 E1341
      -37.7528 K1--- <= 0.0000

Row: E1--2    Elements:  13
        1.0000 E1112
        1.0000 E1122
        1.0000 E1132
        1.0000 E1142
        1.0000 E1212
        1.0000 E1222
        1.0000 E1232
        1.0000 E1242
        1.0000 E1312
        1.0000 E1322
        1.0000 E1332
        1.0000 E1342
      -84.1754 K1--- <= 0.0000

Row: E1--3    Elements:  13
        1.0000 E1113
        1.0000 E1123
        1.0000 E1133
        1.0000 E1143
        1.0000 E1213
        1.0000 E1223
        1.0000 E1233
        1.0000 E1243
        1.0000 E1313
        1.0000 E1323
        1.0000 E1333
        1.0000 E1343
      -89.7329 K1--- <= 0.0000

Row: E2--1    Elements:  10
        1.0000 E2111
        1.0000 E2121
        1.0000 E2131
        1.0000 E2211
        1.0000 E2221
        1.0000 E2231
        1.0000 E2311
        1.0000 E2321
        1.0000 E2331
      -30.0000 K2--- <= 0.0000

Row: E2--2    Elements:  10
        1.0000 E2112
        1.0000 E2122
        1.0000 E2132
        1.0000 E2212
        1.0000 E2222
        1.0000 E2232
        1.0000 E2312
        1.0000 E2322
        1.0000 E2332
      -67.2897 K2--- <= 0.0000

Row: E2--3    Elements:  10
        1.0000 E2113
        1.0000 E2123
        1.0000 E2133
        1.0000 E2213
        1.0000 E2223
        1.0000 E2233
        1.0000 E2313
        1.0000 E2323
        1.0000 E2333
      -62.0690 K2--- <= 0.0000
```

```
Row: E3--1    Elements:  13
        1.0000 E3111
        1.0000 E3121
        1.0000 E3131
        1.0000 E3141
        1.0000 E3211
        1.0000 E3221
        1.0000 E3231
        1.0000 E3241
        1.0000 E3311
        1.0000 E3321
        1.0000 E3331
        1.0000 E3341
      -37.7528 K3--- <= 0.0000

Row: E3--2    Elements:  13
        1.0000 E3112
        1.0000 E3122
        1.0000 E3132
        1.0000 E3142
        1.0000 E3212
        1.0000 E3222
        1.0000 E3232
        1.0000 E3242
        1.0000 E3312
        1.0000 E3322
        1.0000 E3332
        1.0000 E3342
      -84.1754 K3--- <= 0.0000

Row: E3--3    Elements:  13
        1.0000 E3113
        1.0000 E3123
        1.0000 E3133
        1.0000 E3143
        1.0000 E3213
        1.0000 E3223
        1.0000 E3233
        1.0000 E3243
        1.0000 E3313
        1.0000 E3323
        1.0000 E3333
        1.0000 E3343
      -89.7329 K3--- <= 0.0000

Row: E4--1    Elements:  13
        1.0000 E4111
        1.0000 E4121
        1.0000 E4131
        1.0000 E4141
        1.0000 E4211
        1.0000 E4221
        1.0000 E4231
        1.0000 E4241
        1.0000 E4311
        1.0000 E4321
        1.0000 E4331
        1.0000 E4341
      -32.6214 K4--- <= 0.0000

Row: E4--2    Elements:  13
        1.0000 E4112
        1.0000 E4122
        1.0000 E4132
        1.0000 E4142
        1.0000 E4212
        1.0000 E4222
        1.0000 E4232
        1.0000 E4242
        1.0000 E4312
        1.0000 E4322
        1.0000 E4332
        1.0000 E4342
      -73.9817 K4--- <= 0.0000

Row: E4--3    Elements:  13
        1.0000 E4113
        1.0000 E4123
        1.0000 E4133
        1.0000 E4143
        1.0000 E4213
        1.0000 E4223
        1.0000 E4233
        1.0000 E4243
        1.0000 E4313
        1.0000 E4323
        1.0000 E4333
        1.0000 E4343
      -70.1624 K4--- <= 0.0000
```

(83VA)
(83CA)
(83VR)
(83CR)

```
Statistics-
  LP83 Version 5.00
  Machine memory:  640K bytes.
  Pagable memory:  411K bytes.
  Variables:       139
  Constraints:      21
    21 LE,    0 EQ,    0 GE.
  Non-zero LP elements:     282
  Disk Space:      0K bytes.
  Page Space:     23K bytes.
  Capacity: 15.1% used.
  Estimated Time: 00:01:43

Iter   33
Solution Time:  00:00:03
U n i q u e   S o l u t i o n
```

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SOLUTION (Maximized): 4778096.761 NWHI Bottomfish Model - Baseline Version

Variable	Activity	Cost	Variable	Activity	Cost
E1111	0.0000	-271.6022	E1112	0.0000	-217.2817
E1113	0.0000	-244.4419	E1121	0.0000	-324.1139
E1122	0.0000	-259.2911	E1123	0.0000	-134.2525
E1131	0.0000	1,089.1873	E1132	0.0000	1,144.1138
E1133	0.0000	565.6405	E1141	0.0000	751.9609
E1142	0.0000	1,499.1367	E1143	0.0000	693.0188
E1211	0.0000	-271.6022	E1212	0.0000	-217.2817
E1213	0.0000	-244.4419	E1221	0.0000	-324.1139
E1222	0.0000	-259.2911	E1223	0.0000	25.0975
E1231	0.0000	474.2673	E1232	0.0000	254.6138
E1233	0.0000	358.3005	E1241	77.8652	1,452.4809
E1242	0.0000	1,183.3167	E1243	0.0000	811.6688
E1311	0.0000	-271.6022	E1312	0.0000	-217.2817

E1313	538.3976	3,116.1181	E1321	0.0000	-324.1139
E1322	505.0522	306.2089	E1323	0.0000	1,951.1575
E1331	0.0000	-317.7227	E1332	0.0000	97.0538
E1333	0.0000	-21.5395	E1341	148.6517	2,022.8809
E1342	0.0000	14.6167	E1343	0.0000	330.2888
E2111	0.0000	201.0383	E2112	0.0000	-57.9313
E2113	0.0000	-110.7715	E2121	0.0000	-259.2911
E2122	0.0000	-194.4683	E2123	0.0000	-87.9497
E2131	0.0000	-273.3862	E2132	0.0000	-205.0396
E2133	0.0000	-239.2129	E2211	0.0000	-110.0417
E2212	0.0000	28.3987	E2213	0.0000	-190.1215
E2221	75.0000	536.3089	E2222	0.0000	-145.4683
E2223	0.0000	138.5203	E2231	0.0000	-273.3862
E2232	0.0000	-205.0396	E2233	0.0000	-239.2129
E2311	0.0000	-58.0317	E2312	33.6449	282.5987
E2313	186.2069	1,501.8785	E2321	15.0000	109.3089
E2322	168.2243	2,439.0217	E2323	0.0000	507.9803
E2331	0.0000	-273.3862	E2332	0.0000	-205.0396
E2333	0.0000	-239.2129	E3111	0.0000	-271.6022
E3112	0.0000	-217.2817	E3113	0.0000	-160.9819
E3121	85.9076	2,585.2461	E3122	0.0000	-259.2911
E3123	0.0000	-291.7025	E3131	78.0896	2,113.0673
E3132	0.0000	-157.4662	E3133	92.1132	1,019.0405
E3141	0.0000	-381.4791	E3142	0.0000	1,192.2667
E3143	423.7885	1,400.0288	E3211	0.0000	-271.6022
E3212	0.0000	-217.2817	E3213	0.0000	-203.6419

E3221	0.0000	345.5361	E3222	0.0000	-259.2911
E3223	0.0000	-291.7025	E3231	119.1489	883.5573
E3232	0.0000	182.3238	E3233	0.0000	205.6805
E3241	0.0000	-381.4791	E3242	0.0000	322.8667
E3243	21.5754	673.9088	E3311	0.0000	-271.6022
E3312	0.0000	-217.2817	E3313	0.0000	-190.2119
E3321	0.0000	-190.0639	E3322	0.0000	-259.2911
E3323	0.0000	-291.7025	E3331	0.0000	-268.6127
E3332	631.3152	316.8138	E3333	135.5199	139.9205
E3341	0.0000	-381.4791	E3342	0.0000	-237.9233
E3343	0.0000	-42.0812	E4111	0.0000	-244.4419
E4112	221.1765	1,382.3785	E4113	0.0000	-217.2817
E4121	0.0000	-291.7025	E4122	0.0000	-226.8797
E4123	0.0000	-259.2911	E4131	0.0000	305.5205
E4132	0.0000	-231.2129	E4133	10.0232	2,270.4738
E4141	0.0000	2,355.0788	E4142	0.0000	1,934.1546
E4143	0.0000	2,179.3567	E4211	0.0000	-244.4419
E4212	0.0000	-190.1215	E4213	0.0000	-217.2817
E4221	0.0000	-291.7025	E4222	0.0000	-226.8797
E4223	0.0000	-259.2911	E4231	0.0000	-31.5595
E4232	0.0000	-239.2129	E4233	0.0000	-273.3862
E4241	0.0000	840.7488	E4242	74.7501	707.1246
E4243	0.0000	705.8167	E4311	130.4854	1,619.0981
E4312	0.0000	-190.1215	E4313	0.0000	-217.2817
E4321	0.0000	1,462.6975	E4322	0.0000	-226.8797
E4323	270.6265	4,350.6289	E4331	0.0000	-277.0495

E4332	0.0000	-239.2129	E4333	0.0000	-273.3862
E4341	0.0000	-254.5012	E4342	0.0000	-7.6554
E4343	0.0000	-2.7833	K1---	6.0000	-75000.0000
K2---	3.0000	-60000.0000	K3---	7.5000	-75000.0000
K4---	4.0000	-50000.0000			

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CONSTRAINTS: NWHI Bottomfish Model - Baseline Version

Constraint	Activity	RHS	Constraint	Activity	RHS
Q-11-	94,000.0000	<94,000.0000	Q-12-	76,200.0000	<76,200.0000
Q-13-	94,400.0000	<94,400.0000	Q-14-	192400.0000	<192400.0000
Q-21-	0.0000	<62,750.0000	Q-22-	19,125.0000	<49,800.0000
Q-23-	61,600.0000	<61,600.0000	Q-24-	125600.0000	<125600.0000
Q-3--	2275504.590	<11000000.00	E1--1	0.0000 <	0.0000
E1--2	0.0000 <	0.0000	E1--3	0.0000 <	0.0000
E2--1	0.0000 <	0.0000	E2--2	0.0000 <	0.0000
E2--3	0.0000 <	0.0000	E3--1	0.0000 <	0.0000
E3--2	0.0000 <	0.0000	E3--3	0.0000 <	0.0000
E4--1	0.0000 <	0.0000	E4--2	0.0000 <	0.0000
E4--3	0.0000 <	0.0000			

Total Error: 0.000000

COST ANALYSIS: NWHI Bottomfish Model - Baseline Version

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	527.5186	<------	Upper	306.2089	<------
E1111	-271.6022		E1112	-217.2817	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		799.1207	Reduced Cost		523.4906
Upper	3,116.1181	<------	Upper	527.5186	<------
E1113	-244.4419		E1121	-324.1139	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		3,360.5600	Reduced Cost		851.6324
Upper	306.2089	<------	Upper	3,217.1283	<------
E1122	-259.2911		E1123	-134.2525	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		565.5000	Reduced Cost		3,351.3807
Upper	1,484.3386	<------	Upper	1,205.3089	<------
E1131	1,089.1873		E1132	1,144.1138	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		395.1513	Reduced Cost		61.1951
Upper	3,771.0181	<------	Upper	1,421.2517	<------
E1133	565.6405		E1141	751.9609	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		3,205.3775	Reduced Cost		669.2909
Upper	1,796.6894	<------	Upper	3,990.4222	<------
E1142	1,499.1367		E1143	693.0188	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		297.5527	Reduced Cost		3,297.4035
Upper	527.5186	<------	Upper	306.2089	<------
E1211	-271.6022		E1212	-217.2817	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		799.1207	Reduced Cost		523.4906
Upper	3,116.1181	<------	Upper	527.5186	<------
E1213	-244.4419		E1221	-324.1139	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		3,360.5600	Reduced Cost		851.6324
Upper	306.2089	<------	Upper	3,116.1181	<------
E1222	-259.2911		E1223	25.0975	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		565.5000	Reduced Cost		3,091.0205

COST ANALYSIS: NWHI Bottomfish Model - Baseline Version

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	635.1664	<------	Upper	424.9381	<------
E1231	474.2673		E1232	254.6138	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		160.8991	Reduced Cost		170.3243
Upper	3,272.0491	<------	Upper	2,947.8431	E1341
E1233	358.3005		E1241	1,452.4809	
Lower	UNBOUNDED		Lower	1,291.5817	E1231
Reduced Cost		2,913.7485	Reduced Cost		0.0000
Upper	1,484.2754	<------	Upper	3,964.9433	<------
E1242	1,183.3167		E1243	811.6688	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		300.9587	Reduced Cost		3,153.2745
Upper	527.5186	<------	Upper	306.2089	<------
E1311	-271.6022		E1312	-217.2817	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		799.1207	Reduced Cost		523.4906
Upper	UNBOUNDED		Upper	527.5186	<------
E1313	3,116.1181		E1321	-324.1139	
Lower	1,951.1575	E1323	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		851.6324
Upper	UNBOUNDED		Upper	3,116.1181	<------
E1322	306.2089		E1323	1,951.1575	
Lower	245.0138	E1132	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		1,164.9605
Upper	527.5186	<------	Upper	306.2089	<------
E1331	-317.7227		E1332	97.0538	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		845.2413	Reduced Cost		209.1551
Upper	3,116.1181	<------	Upper	UNBOUNDED	
E1333	-21.5395		E1341	2,022.8809	
Lower	UNBOUNDED		Lower	527.5186	<------
Reduced Cost		3,137.6575	Reduced Cost		-1,495.3623
Upper	306.2089	<------	Upper	3,116.1181	<------
E1342	14.6167		E1343	330.2888	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		291.5922	Reduced Cost		2,785.8293

COST ANALYSIS: NWHI Bottomfish Model - Baseline Version

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	360.5368	<------	Upper	364.3235	<------
E2111	201.0383		E2112	-57.9313	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		159.4986	Reduced Cost		422.2547
Upper	1,571.4959	<------	Upper	109.3089	<------
E2113	-110.7715		E2121	-259.2911	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,682.2674	Reduced Cost		368.6000
Upper	282.5987	<------	Upper	1,572.8005	<------
E2122	-194.4683		E2123	-87.9497	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		477.0670	Reduced Cost		1,660.7502
Upper	109.3089	<------	Upper	282.5987	<------
E2131	-273.3862		E2132	-205.0396	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		382.6951	Reduced Cost		487.6383
Upper	1,501.8785	<------	Upper	109.3089	<------
E2133	-239.2129		E2211	-110.0417	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,741.0914	Reduced Cost		219.3506
Upper	282.5987	<------	Upper	1,501.8785	<------
E2212	28.3987		E2213	-190.1215	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		254.2000	Reduced Cost		1,692.0000
Upper	UNBOUNDED		Upper	282.5987	<------
E2221	536.3089		E2222	-145.4683	
Lower	109.3089	<------	Lower	UNBOUNDED	
Reduced Cost		-427.0000	Reduced Cost		428.0670
Upper	1,501.8785	<------	Upper	109.3089	<------
E2223	138.5203		E2231	-273.3862	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,363.3582	Reduced Cost		382.6951
Upper	282.5987	<------	Upper	1,501.8785	<------
E2232	-205.0396		E2233	-239.2129	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		487.6383	Reduced Cost		1,741.0914

COST ANALYSIS: NWHI Bottomfish Model - Baseline Version

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	109.3089	<------	Upper	2,439.0217	E2322
E2311	-58.0317		E2312	282.5987	
Lower	UNBOUNDED		Lower	28.3987	E2212
Reduced Cost		167.3406	Reduced Cost		0.0000
Upper	UNBOUNDED		Upper	536.3089	E2221
E2313	1,501.8785		E2321	109.3089	
Lower	607.4653	K2---	Lower	0.0000	E2--1
Reduced Cost		0.0000	Reduced Cost		0.0000
Upper	UNBOUNDED		Upper	1,501.8785	<------
E2322	2,439.0217		E2323	507.9803	
Lower	282.5987	<------	Lower	UNBOUNDED	
Reduced Cost		-2,156.4230	Reduced Cost		993.8982
Upper	109.3089	<------	Upper	282.5987	<------
E2331	-273.3862		E2332	-205.0396	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		382.6951	Reduced Cost		487.6383
Upper	1,501.8785	<------	Upper	678.9473	<------
E2333	-239.2129		E3111	-271.6022	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,741.0914	Reduced Cost		950.5494
Upper	316.8138	<------	Upper	218.6184	<------
E3112	-217.2817		E3113	-160.9819	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		534.0955	Reduced Cost		379.6004
Upper	UNBOUNDED		Upper	316.8138	<------
E3121	2,585.2461		E3122	-259.2911	
Lower	678.9473	Q-12-	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		576.1049
Upper	139.9205	<------	Upper	2,197.1173	E3233
E3123	-291.7025		E3131	2,113.0673	
Lower	UNBOUNDED		Lower	1,779.6561	E3221
Reduced Cost		431.6230	Reduced Cost		0.0000
Upper	363.4338	<------	Upper	1,223.4226	E3221
E3132	-157.4662		E3133	1,019.0405	
Lower	UNBOUNDED		Lower	967.5176	E3233
Reduced Cost		520.9000	Reduced Cost		0.0000

COST ANALYSIS: NWHI Bottomfish Model - Baseline Version

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	678.9473	<------	Upper	1,557.4931	<------
E3141	-381.4791		E3142	1,192.2667	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,060.4264	Reduced Cost		365.2264
Upper	UNBOUNDED		Upper	678.9473	<------
E3143	1,400.0288		E3211	-271.6022	
Lower	1,303.8475	E4142	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		950.5494
Upper	316.8138	<------	Upper	139.9205	<------
E3212	-217.2817		E3213	-203.6419	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		534.0955	Reduced Cost		343.5625
Upper	678.9473	<------	Upper	316.8138	<------
E3221	345.5361		E3222	-259.2911	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		333.4111	Reduced Cost		576.1049
Upper	139.9205	<------	Upper	UNBOUNDED	
E3223	-291.7025		E3231	883.5573	
Lower	UNBOUNDED		Lower	799.5073	E3233
Reduced Cost		431.6230	Reduced Cost		0.0000
Upper	395.5709	<------	Upper	251.5260	<------
E3232	182.3238		E3233	205.6805	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		213.2470	Reduced Cost		45.8455
Upper	678.9473	<------	Upper	723.2210	<------
E3241	-381.4791		E3242	322.8667	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,060.4264	Reduced Cost		400.3544
Upper	757.7617	E4--2	Upper	678.9473	<------
E3243	673.9088		E3311	-271.6022	
Lower	537.4917	E1242	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		950.5494
Upper	316.8138	<------	Upper	139.9205	<------
E3312	-217.2817		E3313	-190.2119	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		534.0955	Reduced Cost		330.1325

COST ANALYSIS: NWHI Bottomfish Model - Baseline Version

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	678.9473	<------	Upper	316.8138	<------
E3321	-190.0639		E3322	-259.2911	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		869.0111	Reduced Cost		576.1049
Upper	139.9205	<------	Upper	678.9473	<------
E3323	-291.7025		E3331	-268.6127	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		431.6230	Reduced Cost		947.5600
Upper	437.3293	K3---	Upper	199.7558	E1132
E3332	316.8138		E3333	139.9205	
Lower	103.5668	E3232	Lower	56.0676	E4--2
Reduced Cost		0.0000	Reduced Cost		0.0000
Upper	678.9473	<------	Upper	316.8138	<------
E3341	-381.4791		E3342	-237.9233	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,060.4264	Reduced Cost		554.7371
Upper	139.9205	<------	Upper	1,619.0981	<------
E3343	-42.0812		E4111	-244.4419	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		182.0018	Reduced Cost		1,863.5400
Upper	UNBOUNDED		Upper	614.3538	<------
E4112	1,382.3785		E4113	-217.2817	
Lower	565.6690	E2111	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		831.6355
Upper	1,619.0981	<------	Upper	95.9704	<------
E4121	-291.7025		E4122	-226.8797	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,910.8005	Reduced Cost		322.8501
Upper	614.3538	<------	Upper	1,878.8381	<------
E4123	-259.2911		E4131	305.5205	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		873.6449	Reduced Cost		1,573.3175
Upper	118.1704	<------	Upper	6,006.7489	E4323
E4132	-231.2129		E4133	2,270.4738	
Lower	UNBOUNDED		Lower	1,687.1864	E4143
Reduced Cost		349.3834	Reduced Cost		0.0000

COST ANALYSIS: NWHI Bottomfish Model - Baseline Version

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	3,459.3002	<------	Upper	2,086.0533	<------
E4141	2,355.0788		E4142	1,934.1546	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,104.2214	Reduced Cost		151.8987
Upper	2,762.6441	<------	Upper	1,619.0981	<------
E4143	2,179.3567		E4211	-244.4419	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		583.2874	Reduced Cost		1,863.5400
Upper	95.9704	<------	Upper	614.3538	<------
E4212	-190.1215		E4213	-217.2817	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		286.0920	Reduced Cost		831.6355
Upper	1,619.0981	<------	Upper	95.9704	<------
E4221	-291.7025		E4222	-226.8797	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,910.8005	Reduced Cost		322.8501
Upper	614.3538	<------	Upper	1,666.5897	<------
E4223	-259.2911		E4231	-31.5595	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		873.6449	Reduced Cost		1,698.1492
Upper	95.9704	<------	Upper	614.3538	<------
E4232	-239.2129		E4233	-273.3862	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		335.1834	Reduced Cost		887.7400
Upper	2,420.5948	<------	Upper	1,523.8341	E2111
E4241	840.7488		E4242	707.1246	
Lower	UNBOUNDED		Lower	611.1542	E4--2
Reduced Cost		1,579.8461	Reduced Cost		0.0000
Upper	1,307.8183	<------	Upper	UNBOUNDED	
E4243	705.8167		E4311	1,619.0981	
Lower	UNBOUNDED		Lower	1,462.6975	E4321
Reduced Cost		602.0016	Reduced Cost		0.0000
Upper	95.9704	<------	Upper	614.3538	<------
E4312	-190.1215		E4313	-217.2817	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		286.0920	Reduced Cost		831.6355

COST ANALYSIS: NWHI Bottomfish Model - Baseline Version

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	1,619.0981	<------	Upper	95.9704	<------
E4321	1,462.6975		E4322	-226.8797	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		156.4005	Reduced Cost		322.8501
Upper	UNBOUNDED		Upper	1,619.0981	<------
E4323	4,350.6289		E4331	-277.0495	
Lower	614.3538	<------	Lower	UNBOUNDED	
Reduced Cost		-3,736.2751	Reduced Cost		1,896.1475
Upper	95.9704	<------	Upper	614.3538	<------
E4332	-239.2129		E4333	-273.3862	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		335.1834	Reduced Cost		887.7400
Upper	1,619.0981	<------	Upper	95.9704	<------
E4341	-254.5012		E4342	-7.6554	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,873.5993	Reduced Cost		103.6258
Upper	614.3538	<------	Upper	UNBOUNDED	
E4343	-2.7833		K1---	-75000.0000	
Lower	UNBOUNDED		Lower	-325308.983	<------
Reduced Cost		617.1371	Reduced Cost		-250,308.9831
Upper	UNBOUNDED		Upper	-64855.5668	<------
K2---	-60000.0000		K3---	-75000.0000	
Lower	-115515.299	<------	Lower	UNBOUNDED	
Reduced Cost		-55,515.2991	Reduced Cost		10,144.4332
Upper	UNBOUNDED				
K4---	-50000.0000				
Lower	-103021.777	<------			
Reduced Cost		-53,021.7773			

MARGINAL ANALYSIS: NWHI Bottomfish Model - Baseline Version

Constraint at limit	Value	Constraint at limit	Value
Q-11- <	94,000.0000	Q-12- <	76,200.0000
Increases objective ... by	3.0268	Increases objective ... by	2.1492
Upper Limit.		Upper Limit.	
New limit ..	125768.8073	New limit ..	145465.4554
New optimum ...	4874255.936	New optimum ...	4926958.835
Forced to limit	E4242	Forced to limit	E3131
Lower Limit.		Lower Limit.	
New limit ..	85,988.2253	New limit ..	26,114.9488
New optimum ...	4753846.382	New optimum ...	4670456.314
Forced to limit	E3243	Forced to limit	E3133
Q-13- <	94,400.0000	Q-14- <	192400.0000
Increases objective ... by	2.2200	Increases objective ... by	2.7756
Upper Limit.		Upper Limit.	
New limit ..	148065.8774	New limit ..	253926.0312
New optimum ...	4897235.009	New optimum ...	4948866.493
Forced to limit	E3333	Forced to limit	E3333
Lower Limit.		Lower Limit.	
New limit ..	57,923.1758	New limit ..	0.0000
New optimum ...	4697118.212	New optimum ...	4244077.326
Forced to limit	E3133	Forced to limit	E3143
Q-23- <	61,600.0000	Q-24- <	125600.0000
Increases objective ... by	0.3958	Increases objective ... by	1.0289
Upper Limit.		Upper Limit.	
New limit ..	101972.3117	New limit ..	195934.8242
New optimum ...	4794074.670	New optimum ...	4850462.789
Forced to limit	E3131	Forced to limit	E3333
Lower Limit.		Lower Limit.	
New limit ..	32,407.2475	New limit ..	114402.3667
New optimum ...	4766543.320	New optimum ...	4766575.751
Forced to limit	E3133	Forced to limit	E3243

MARGINAL ANALYSIS: NWHI Bottomfish Model - Baseline Version

Constraint at limit	Value	Constraint at limit	Value
E1--1 <	0.0000	E1--2 <	0.0000
Increases objective ...		Increases objective ...	
by	527.5186	by	306.2089
Upper Limit.		Upper Limit.	
New limit ..	12.4557	New limit ..	25.2526
New optimum ...	4784667.351	New optimum ...	4785829.336
Forced to limit	E3243	Forced to limit	E1322
Lower Limit.		Lower Limit.	
New limit ..	-77.8652	New limit ..	-505.0522
New optimum ...	4737021.438	New optimum ...	4623445.278
Forced to limit	E1241	Forced to limit	E1322
E1--3 <	0.0000	E2--1 <	0.0000
Increases objective ...		Increases objective ...	
by	3,116.1181	by	109.3089
Upper Limit.		Upper Limit.	
New limit ..	874.8961	New limit ..	60.0000
New optimum ...	7504376.428	New optimum ...	4784655.296
Forced to limit	E1313	Forced to limit	E2321
Lower Limit.		Lower Limit.	
New limit ..	-538.3976	New limit ..	-15.0000
New optimum ...	3100386.197	New optimum ...	4776457.128
Forced to limit	E1313	Forced to limit	E2321
E2--2 <	0.0000	E2--3 <	0.0000
Increases objective ...		Increases objective ...	
by	282.5987	by	1,501.8785
Upper Limit.		Upper Limit.	
New limit ..	471.0280	New limit ..	279.3103
New optimum ...	4911208.674	New optimum ...	5197586.960
Forced to limit	E2312	Forced to limit	E2313
Lower Limit.		Lower Limit.	
New limit ..	-33.6449	New limit ..	-186.2069
New optimum ...	4768588.768	New optimum ...	4498436.629
Forced to limit	E2312	Forced to limit	E2313

MARGINAL ANALYSIS: NWHI Bottomfish Model - Baseline Version

Constraint at limit	Value	Constraint at limit	Value
E3--1 <	0.0000	E3--2 <	0.0000
Increases objective ...		Increases objective ...	
by	678.9473	by	316.8138
Upper Limit.		Upper Limit.	
New limit ..	56.4657	New limit ..	473.4864
New optimum ...	4816433.975	New optimum ...	4928103.804
Forced to limit	E3133	Forced to limit	E3332
Lower Limit.		Lower Limit.	
New limit ..	-78.0896	New limit ..	-631.3152
New optimum ...	4725078.056	New optimum ...	4578087.371
Forced to limit	E3131	Forced to limit	E3332
E3--3 <	0.0000	E4--1 <	0.0000
Increases objective ...		Increases objective ...	
by	139.9205	by	1,619.0981
Upper Limit.		Upper Limit.	
New limit ..	1,042.2249	New limit ..	309.9029
New optimum ...	4923925.438	New optimum ...	5279859.965
Forced to limit	E3333	Forced to limit	E4311
Lower Limit.		Lower Limit.	
New limit ..	-135.5199	New limit ..	-130.4854
New optimum ...	4759134.744	New optimum ...	4566828.044
Forced to limit	E3333	Forced to limit	E4311
E4--2 <	0.0000	E4--3 <	0.0000
Increases objective ...		Increases objective ...	
by	95.9704	by	614.3538
Upper Limit.		Upper Limit.	
New limit ..	18.8512	New limit ..	48.8965
New optimum ...	4779905.923	New optimum ...	4808136.542
Forced to limit	E3243	Forced to limit	E3133
Lower Limit.		Lower Limit.	
New limit ..	-74.7501	New limit ..	-10.0232
New optimum ...	4770922.958	New optimum ...	4771938.969
Forced to limit	E4242	Forced to limit	E4133

Updating Spreadsheet: C:BASEBTM.WKS(83VA)

APPENDIX - ITEM C5: BASELINE VARIABLE AND PARAMETER LISTING

RBTBASE VARIABLE	SOLUTION FISH DAYS	CATCH RATE (q)	PRICE (p)	OPERATE COST (c)	ANNUAL FIXED COST PER BOAT
E1111		0	0.00	272	
E1112		0	0.00	217	
E1113		0	0.00	244	
E1121		0	0.00	324	
E1122		0	0.00	259	
E1123		47	3.35	292	
E1131		431	3.32	342	
E1132		405	3.50	273	
E1133		295	2.96	308	
E1141		322	3.52	381	
E1142		537	3.36	305	
E1143		315	3.29	343	
E1211		0	0.00	272	
E1212		0	0.00	217	
E1213		0	0.00	244	
E1221		0	0.00	324	
E1222		0	0.00	259	
E1223		144	2.20	292	
E1231		272	3.00	342	
E1232		300	1.76	273	
E1233		394	1.69	308	
E1241	78	899	2.04	381	
E1242		1145	1.30	305	
E1243		825	1.40	343	
E1311		0	0.00	272	
E1312		0	0.00	217	
E1313	538	1412	2.38	244	
E1321		0	0.00	324	
E1322	505	377	1.50	259	
E1323		1289	1.74	292	
E1331		7	3.43	342	
E1332		189	1.96	273	
E1333		126	2.27	308	
E1341	149	1108	2.17	381	
E1342		164	1.95	305	
E1343		309	2.18	343	
E2111		83	5.04	217	
E2112		27	3.89	163	
E2113		23	3.45	190	
E2121		0	0.00	259	
E2122		0	0.00	194	
E2123		33	4.21	227	
E2131		0	0.00	273	
E2132		0	0.00	205	
E2133		0	0.00	239	
E2211		28	3.83	217	

E2212		92	2.08	163
E2213		0	0.00	190
E2221	75	255	3.12	259
E2222		35	1.40	194
E2223		145	2.52	227
E2231		0	0.00	273
E2232		0	0.00	205
E2233		0	0.00	239
E2311		35	4.55	217
E2312	34	188	2.37	163
E2313	186	705	2.40	190
E2321	15	97	3.80	259
E2322	168	1009	2.61	194
E2323		362	2.03	227
E2331		0	0.00	273
E2332		0	0.00	205
E2333		0	0.00	239
E3111		0	0.00	272
E3112		0	0.00	217
E3113		26	3.21	244
E3121	86	887	3.28	324
E3122		0	0.00	259
E3123		0	0.00	292
E3131	78	646	3.80	342
E3132		21	5.52	273
E3133	92	396	3.35	308
E3141		0	0.00	381
E3142		447	3.35	305
E3143	424	454	3.84	343
E3211		0	0.00	272
E3212		0	0.00	217
E3213		16	2.55	244
E3221		295	2.27	324
E3222		0	0.00	259
E3223		0	0.00	292
E3231	119	517	2.37	342
E3232		199	2.29	273
E3233		282	1.82	308
E3241		0	0.00	381
E3242		395	1.59	305
E3243	22	519	1.96	343
E3311		0	0.00	272
E3312		0	0.00	217
E3313		29	1.87	244
E3321		35	3.83	324
E3322		0	0.00	259
E3323		0	0.00	292
E3331		16	4.57	342
E3332	631	130	4.54	273
E3333	136	226	1.98	308
E3341		0	0.00	381
E3342		38	1.77	305

E3343		125	2.41	343	
E4111		0	0.00	244	
E4112	221	425	3.70	190	
E4113		0	0.00	217	
E4121		0	0.00	292	
E4122		0	0.00	227	
E4123		0	0.00	259	
E4131		117	5.24	308	
E4132		10	0.80	239	
E4133	10	746	3.41	273	
E4141		663	4.07	343	
E4142		717	3.07	267	
E4143		774	3.21	305	
E4211		0	0.00	244	
E4212		0	0.00	190	
E4213		0	0.00	217	
E4221		0	0.00	292	
E4222		0	0.00	227	
E4223		0	0.00	259	
E4231		120	2.30	308	
E4232		0	0.00	239	
E4233		0	0.00	273	
E4241		779	1.52	343	
E4242	75	594	1.64	267	
E4243		674	1.50	305	
E4311	130	783	2.38	244	
E4312		0	0.00	190	
E4313		0	0.00	217	
E4321		1020	1.72	292	
E4322		0	0.00	227	
E4323	271	2352	1.96	259	
E4331		9	3.39	308	
E4332		0	0.00	239	
E4333		0	0.00	273	
E4341		21	4.23	343	
E4342		99	2.62	267	
E4343		112	2.70	305	
K1---	6				75000
K2---	3				60000
K3---	7.5				75000
K4---	4				50000

PROFIT $4,778,097

A P P E N D I X B

APPENDIX B: A SIMPLE FISHERY LINEAR PROGRAM MODEL

Imagine a fishery with two types of vessels (F1 and F2) and two target species (C1 and C2). Both types of vessels <u>can</u> fish for either or both species during the year, but their costs of operation (OpCost), prices received (Price), and catch rates (q) differ. Furthermore, the number of fish of each species is also limited (Q1 and Q2). This could either be interpreted as MSY or as quotas.

The model is set up in a spreadsheet format. Part A shows the variables essential to maximizing net revenue. The number of vessels in the solution is shown in the first line of figures. The production variables are shown in the next three lines, and the net revenue of the solution is shown in the following line. Part B shows the constraints on total production, the amount of fish available for each species (Q1 and Q2) and the number of vessels (F1 and F2). Part C compares the solution values with the available resources.

Two "runs" of the model are shown. In the first, total net revenue is $7,125. All of the F1 vessels (20) fish for species 2 (C2), while 6.25 F2 vessels (indicating perhaps that one vessel fished one quarter of the year) fish for species 1 (C1) and 8.75 F2 vessels fished for species 2 (C2). Only a small percentage of C1 was caught, while all of C2 (7500 lbs) was caught, indicating C2 is a constraint on the solution. All of both fleets were active, indicating fleet size was also a constraint on the solution.

The difference between the two runs lies in the price of fish received by Fleet 1 for its catch of species 1 (C1). Despite this small change, the solution changes rather substantially, with more of F1 effort applied to C1 rather than C2, and thus all of F2 effort applied to C2.

Run 1: SAMPLE LINEAR PROGRAMMING PROBLEM IN SPREADSHEET FORMAT

PART A ....

Species/Fleet Choices	C1F1	C1F2	C2F1	C2F2	
Vessels in Solution		6.25	20	8.75	
q	100	150	200	400	
Price	$4.00	$4.00	$2.50	$1.75	
OpCost	$300	$450	$300	$450	
Net revenue per vessel	$200	$150	$200	$250	
Solution Net Revenue	$0	$938	$4,000	$2,188	
Total Net Revenue	....	....	....	....	$7,125

PART B ....

CONSTRAINTS

Q1	100	150			<=	5000
Q2			200	400	<=	7500
F1	1		1		<=	20
F2		1		1	<=	15

PART C ....

					Solution	Available
Q1	0	937.5			937.5	5000
Q2			4000	3500	7500	7500
V1	0		20		20	20
V2		6.25		8.75	15	15

Run2: Revised C1F1 price

PART A ....

Species/Fleet Choices	C1F1	C1F2	C2F1	C2F2	
Vessels in Solution	12.5		7.5	15	
q	100	150	200	400	
Price	$5.00	$4.00	$2.50	$1.75	
OpCost	$300	$450	$300	$450	
Net revenue per vessel	$200	$150	$200	$250	
Solution Net Revenue	$2,500	$0	$1,500	$3,750	
Total Net Revenue	....				$7,750

PART B ....

CONSTRAINTS

Q1	100	150			<=	5000
Q2			200	400	<=	7500
F1	1		1		<=	20
F2		1		1	<=	15

PART C ....

					Solution	Available
Q1	1250	0			1250	5000
Q2			1500	6000	7500	7500
V1	12.5		7.5		20	20
V2		0		15	15	15

APPENDIX C

APPENDIX - ITEM C1: BASELINE SPREADSHEET (VALUES)

A	B	C	D	E	F	G	H	I
2	BASEBTM.WKS		** TITLE SECTION **			NWHI Bottomfish Model		
3	06-Dec-88							
4			** OPERATING ENVIRONMENT SECTION **					
5								
6					FLEET SIZE	MINIMUM	MAXIMUM	
7				FLEET 1 =	Large Multipur	3	6	
8				FLEET 2 =	Medium Multipur	1.5	3	
9				FLEET 3 =	Tuna Longline	7.5	15	
10				FLEET 4 =	Motor-Sailers	2	4	
11						Minimum =	0.5	
12								
13								
14						TOTAL POTENTIAL FISHING		
15						DAYS PER BOAT PER SEASON [FiSi]		
16					SEASON	1=Holiday	2=Summer	3=Winter
17					Large Multipur	38	84	90
18					Medium Multipur	30	67	62
19					Tuna Longline	38	84	90
20					Motor-Sailers	33	74	70
21								
22								
23						ACTUAL FISHING DAYS (PER BOAT)		
24						Holiday	Summer	Winter
25						37.8	84.2	89.7
26						30.0	67.3	62.1
27						37.8	84.2	89.7
28						32.6	74.0	70.2
29								
30								
31								
32				LP83 DATA SECTION (Fishing Day basis)				
33					VARIABLE LIST->	E1111	E1112	E1113
34				** ECONOMIC PARAMETERS		-----------	-----------	-----------
35				** SOLUTION VALUES				
36				* DAILY CATCH RATE (q)		0	0	0
37				* FISH PRICE (p)		0.00	0.00	0.00
38				* DAILY OPERATING COST (c)		272	217	244
39				* ANNUAL FIXED COST/VESSEL		0	0	0
40				*				
41			** OBJECTIVE FUNCTION - MAX FLEETWIDE PROFIT *******					
42						-272	-217	-244
43								
44			** BOUNDS ****************			Effort Level Bounds (Based on Cal		
45					Fishing Days			
46				* LOWER BOUNDS		0	0	0
47								
48				* UPPER BOUNDS		595	1326	1413
49			Fishing Days by Fleet,Area,Season			37	55	28

A	J	K	L	M	N	O	P	Q	R	S
2	- Baseline Version									
3										
4										
5										
6	SPECIES				FISHING AREAS				SEASONS	
7	SPECIES 1 = OPAKA,ONAGA				AREA 1 = Main Hawaiian Islands (to 161°)				Holiday =	1
8	SPECIES 2 = ALL OTHER BOTTOMFISH				AREA 2 = Mau (161°-165°)				Summer =	2
9	SPECIES 3 = ALL PELAGICS				AREA 3 = Lower Hoomalu (165°-170°)				Winter =	3
10					AREA 4 = Upper Hoomalu (170°-180°)					
11										
12										
13										
14			TOTAL POTENTIAL					AVERAGE (PER TRIP)		
15			OPERATING DAYS PER SEASON [OFiSi]					OPERATING DAYS [ODii]		
16		Holiday	Summer	Winter			Holiday	Summer	Winter	
17		60	120	180			22.3	29.9	21.1	
18		60	120	180			20.0	26.8	21.8	
19		60	120	180			22.3	29.9	21.1	
20		60	120	180			25.8	34.1	26.9	
21										
22							Annual Average =		25.1	
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33	E1121	E1122	E1123	E1131	E1132	E1133	E1141	E1142	E1143	E1211
34	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
35										
36	0	0	47	431	405	295	322	537	315	0
37	0.00	0.00	3.35	3.32	3.50	2.96	3.52	3.36	3.29	0.00
38	324	259	292	342	273	308	381	305	343	272
39	0	0	0	0	0	0	0	0	0	0
40										
41										
42	-324	-259	-134	1089	1144	566	752	1499	693	-272
43										
44	endar Constraints)									
45										
46	0	0	0	0	0	0	0	0	0	0
47										
48	238	530	565	198	442	471	149	331	353	595
49	15	22	11	12	18	9	9	14	7	37
50										

A	T	U	V	W	X	Y	Z	AA	AB	AC
2										
3										
4										
5										
6		CALENDAR DAYS PER SEASON					FISHING DAYS PER TRIP			
7		60	120	180			(ANNUAL AVERAGE) [AFDFi]			
8		Dec-Jan=1	May-Aug=2	Feb-Apr			14			
9				Sept-Nov=3			10			
10							14			
11							14			
12										
13										
14			AVERAGE (PER TRIP)					AVERAGE (PER TRIP)		
15			TURN-AROUND DAYS [TDii]					FISHING DAYS [FDii]		
16		Holiday	Summer	Winter			Holiday	Summer	Winter	
17		3	5	4			14.0	21.0	10.5	
18		5	8	8			10.0	15.0	7.5	
19		3	5	4			14.0	21.0	10.5	
20		5	8	8			14.0	21.0	10.5	
21										
22						RATE =	1.00	1.50	0.75	
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33	E1212	E1213	E1221	E1222	E1223	E1231	E1232	E1233	E1241	E1242
34	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
35									77.8651685	
36	0	0	0	0	144	272	300	394	899	1145
37	0.00	0.00	0.00	0.00	2.20	3.00	1.76	1.69	2.04	1.30
38	217	244	324	259	292	342	273	308	381	305
39	0	0	0	0	0	0	0	0	0	0
40										
41										
42	-217	-244	-324	-259	25	474	255	358	1452	1183
43										
44										
45										
46	0	0	0	0	0	0	0	0	0	0
47										
48	1326	1413	238	530	565	198	442	471	149	331
49	55	28	15	22	11	12	18	9	9	14
50										

A	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM
2										
3										
4										
5										
6	RUNNING DAYS BY AREA PER TRIP [RDiAi]							POTENTIAL TRIPS [PTii]		
7	MHI	MAU	LOWER	UPPER	AVERAGE [ARDFi]				PER SEASON	
8	2	5	6	8	5.3			Holiday	Summer	Winter
9	2	6	7	-	5.0			2.7	4.0	8.5
10	2	5	6	8	5.3			3.0	4.5	8.3
11	2	7	8	10	6.8			2.7	4.0	8.5
12	2.0	5.8	6.8	8.7	5.6			2.3	3.5	6.7
13										
14			AVERAGE (PER TRIP)							
15			RUNNING DAYS [RDii]					ACTUAL TRIPS (PER BOAT)		
16		Holiday	Summer	Winter					PER SEASON	
17		5.3	3.9	6.6				Holiday	Summer	Winter
18		5.0	3.8	6.3				2.7	4.0	8.5
19		5.3	3.9	6.6				3.0	4.5	8.3
20		6.8	5.1	8.4				2.7	4.0	8.5
21								2.3	3.5	6.7
22	RATE =	1.00	0.75	1.25						
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33	E1243	E1311	E1312	E1313	E1321	E1322	E1323	E1331	E1332	E1333
34	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
35				538.397626		505.052192				
36	825	0	0	1412	0	377	1289	7	189	126
37	1.40	0.00	0.00	2.38	0.00	1.50	1.74	3.43	1.96	2.27
38	343	272	217	244	324	259	292	342	273	308
39	0	0	0	0	0	0	0	0	0	0
40										
41										
42	812	-272	-217	3116	-324	306	1951	-318	97	-22
43										
44										
45										
46	0	0	0	0	0	0	0	0	0	0
47										
48	353	595	1326	1413	238	530	565	198	442	471
49	7	37	55	28	15	22	11	12	18	9
50										

A	AN	AO	AP	AQ	AR	AS	AT	AU	AV
2									
3									
4									
5									
6			ANNUAL FIXED COSTS [FCVi]						
7			(PER VESSEL)						
8			75000						
9			60000						
10			75000						
11			50000						
12									
13									
14									
15			AVERAGE (PER DAY)			AREA COST			
16			OPERATING COSTS [OPCii]			RATIO [CRAi]			
17		Holiday	Summer	Winter					
18		250	200	225		AREA 1 =	1.09		
19		200	150	175		AREA 2 =	1.30		
20		250	200	225		AREA 3 =	1.37		
21		225	175	200		AREA 4 =	1.53		
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33	E1341	E1342	E1343	E2111	E2112	E2113	E2121	E2122	E2123
34	----------	----------	----------	----------	----------	----------	----------	----------	----------
35	148.651685								
36	1108	164	309	83	27	23	0	0	33
37	2.17	1.95	2.18	5.04	3.89	3.45	0.00	0.00	4.21
38	381	305	343	217	163	190	259	194	227
39	0	0	0	0	0	0	0	0	0
40									
41									
42	2023	15	330	201	-58	-111	-259	-194	-88
43									
44									
45									
46	0	0	0	0	0	0	0	0	0
47									
48	149	331	353	225	505	466	75	168	155
49	9	14	7	25	38	19	8	13	6
50									

	A	B	C	D	E	F	G	H	I	J
50				** CONSTRAINTS ***************						
51										
52					* Q LIMITS	Q-11-	0	0	0	
53						Q-12-				0
54						Q-13-				
55						Q-14-				
56						Q-21-				
57						Q-22-				
58						Q-23-				
59						Q-24-				
60						Q-3--				
61					* E LIMITS	E1--1	1			1
62						E1--2		1		
63						E1--3			1	
64						E2--1				
65						E2--2				
66						E2--3				
67						E3--1				
68						E3--2				
69						E3--3				
70						E4--1				
71						E4--2				
72						E4--3				
73										
74										
75										

A	EG	EH	EI	EJ	EK	EL	EM	EN	EO	EP	EQ
27											
28											
29											
30											
31											
32											
33	E4332	E4333	E4341	E4342	E4343	K1---	K2---	K3---	K4---	NET PROFIT	
34	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	
35						6	3	7.5	4	4778096.76	
36	0	0	21	99	112						
37	0.00	0.00	4.23	2.62	2.70						
38	239	273	343	267	305						
39	0	0	0	0	0	75000	60000	75000	50000		
40											
41											
42	-239	-273	-255	-8	-3	-75000	-60000	-75000	-50000		
43											
44											
45											
46	0	0	0	0	0	3	1.5	7.5	2		
47											
48	250	237	88	200	189	6	3	15	4		
49	18	9	9	14	7						
50											
51											
52										<=	94000
53										<=	76200
54										<=	94400
55										<=	192400
56										<=	62750
57										<=	49800
58										<=	61600
59										<=	125600
60	0	0	21	99	112					<=	11000000
61						-38				<=	0
62						-84				<=	0
63						-90				<=	0
64							-30			<=	0
65							-67			<=	0
66							-62			<=	0
67								-38		<=	0
68								-84		<=	0
69								-90		<=	0
70			1						-33	<=	0
71	1			1					-74	<=	0
72		1			1				-70	<=	0
73											
74											
75											
76											

APPENDIX - ITEM C2: BASELINE SPREADSHEET (EQUATIONS)

A	B C D E F	G	
2	BASEBTM.WKS ** TITLE SECTION **		
3	@NOW		
4	** OPERATING ENVIRONMENT SECTION **		
5			
6	FLEET SIZE	MINIMUM	
7	FLEET 1 = Large Multipur	+FLT1*H11	
8	FLEET 2 = Medium Multipur	+FLT2*H11	
9	FLEET 3 = Tuna Longline	+FLT3*H11	
10	FLEET 4 = Motor-Sailers	+FLT4*H11	
11			Minimum =
12			
13			
14		TOTAL POTENTIAL FISHING	
15		DAYS PER BOAT PER SEASON [FiSi]	
16	SEASON	1=Holiday	
17	Large Multipur	+PT1H*FD1H	
18	Medium Multipur	+PT2H*FD2H	
19	Tuna Longline	+PT3H*FD3H	
20	Motor-Sailers	+PT4H*FD4H	
21			
22			
23		ACTUAL FISHING DAYS (PER BOAT)	
24		Holiday	
25		(G35+J35+M35+P35+S35+V35+Y35+AB35+AE35+AH35+AK35+AN35)/EL35	
26		(AQ35+AT35+AW35+AZ35+BC35+BF35+BI35+BL35+BO35)/EM35	
27		(BR35+BU35+BX35+CA35+CD35+CG35+CJ35+CM35+CP35+CS35+CV35+CY35)/EN35	
28		(DB35+DE35+DH35+DK35+DN35+DQ35+DT35+DW35+DZ35+EC35+EF35+EI35)/EO35	
29			
30			
31			
32	LP83 DATA SECTION (Fishing Day basis)		
33	VARIABLE LIST->	E1111	
34	** ECONOMIC PARAMETERS	---	
35	** SOLUTION VALUES		
36	* DAILY CATCH RATE (q)	0	
37	* FISH PRICE (p)	0	
38	* DAILY OPERATING COST (c)	+$OPC1H*$CRA1	
39	* ANNUAL FIXED COST/VESSEL	0	
40	*		
41	** OBJECTIVE FUNCTION - MAX FLEETWIDE PROFIT *******		
42		(G36*G37)-(G38+G39)	
43			
44	** BOUNDS *****************	Effort Level Bounds (Based on Calendar Constraints)	
45	Fishing Days		
46	* LOWER BOUNDS	0	
47			
48	* UPPER BOUNDS	+$FLT1*G49*$PT1H	
49	Fishing Days by Fleet,Area,Season	(FD1H*(ARDF1/RD1A1))	

A	H	I	J	K	L	M	N	O	P
2	NWHI Bottomfish Model - Baseline Version								
3									
4									
5									
6	MAXIMUM		SPECIES					FISHING AREAS	
7	6		SPECIES 1 = OPAKA,ONAGA				AREA 1 = Main Hawaiian Islands (to 161°		
8	3		SPECIES 2 = ALL OTHER BOTTOMFISH				AREA 2 = Mau (161°-165°)		
9	15		SPECIES 3 = ALL PELAGICS				AREA 3 = Lower Hoomalu (165°-170°)		
10	4						AREA 4 = Upper Hoomalu (170°-180°)		
11	0.5								
12									
13									
14					TOTAL POTENTIAL				
15				OPERATING DAYS PER SEASON [OFiSi]					OPERAT
16	2=Summer	3=Winter		Holiday	Summer	Winter			Holiday
17	+PT1S*FD1S	+PT1W*FD1W		+PT1H*OD1H	(PT1S*OD1S)	+PT1W*OD1W			+FD1H+RD1H+TD1H
18	+PT2S*FD2S	+PT2W*FD2W		+PT2H*OD2H	(PT2S*OD2S)	+PT2W*OD2W			+FD2H+RD2H+TD2H
19	+PT3S*FD3S	+PT3W*FD3W		(PT3H*OD3H)	(PT3S*OD3S)	+PT3W*OD3W			+FD3H+RD3H+TD3H
20	+PT4S*FD4S	+PT4W*FD4W		(PT4H*OD4H)	(PT4S*OD4S)	+PT4W*OD4W			+FD4H+RD4H+TD4H
21									
22									Annual
23									
24	Summer	Winter							
25	(H35+K35+N	(I35+L35+O							
26	(AR35+AU35	(AS35+AV35							
27	(BS35+BV35	(BT35+BW35							
28	(DC35+DF35	(DD35+DG35							
29									
30									
31									
32									
33	E1112	E1113	E1121	E1122	E1123	E1131	E1132	E1133	E1141
34	--								
35									
36	0	0	0	0	47	431	405	295	322
37	0	0	0	0	3.35	3.32	3.5	2.96	3.52
38	+SOFC1S*SC	+SOFC1W*SC	+SOFC1H*SC	+SOFC1S*SCR	+SOFC1W*SCR	+SOFC1H*SC	+SOFC1S*SC	+SOFC1W*SC	+SOFC1H*SCRA4
39	0	0	0	0	0	0	0	0	0
40									
41									
42	(H36*H37)-	(I36*I37)-	(J36*J37)-	(K36*K37)-(	(L36*L37)-(	(M36*M37)-	(N36*N37)-	(O36*O37)-	(P36*P37)-(P38+
43									
44									
45									
46	0	0	0	0	0	0	0	0	0
47									
48	+$FLT1*H49	+$FLT1*I49	+$FLT1*J49	+$FLT1*K49*	+$FLT1*L49*	+$FLT1*M49	+$FLT1*N49	+$FLT1*O49	+$FLT1*P49*$PT1
49	(FD1S*(ARD	(FD1W*(ARD	(FD1H*(ARD	(FD1S*(ARDF	(FD1W*(ARDF	(FD1H*(ARD	(FD1S*(ARD	(FD1W*(ARD	(FD1H*(ARDF1/RD
50									

A	P	Q	R	S	T	U	V	W	X
2									
3									
4									
5									
6	AS			SEASONS			CALENDAR DAYS PER SEASON		
7	Islands (to 161°)		Holiday =	1		60	120	180	
8			Summer =	2		Dec-Jan=1	May-Aug=2	Feb-Apr	
9	(165°-170°)		Winter =	3				Sept-Nov=3	
10	(170°-180°)								
11									
12									
13									
14	AVERAGE (PER TRIP)						AVERAGE (PER TRIP)		
15	OPERATING DAYS [ODii]						TURN-AROUND DAYS [TDii]		
16	Holiday	Summer	Winter			Holiday	Summer	Winter	
17	+FD1H+RD1H+TD1H	+FD1S+RD1S+TD1S	+FD1W+RD1W+TD1W			3	5	4	
18	+FD2H+RD2H+TD2H	+FD2S+RD2S+TD2S	+FD2W+RD2W+TD2W			5	8	8	
19	+FD3H+RD3H+TD3H	+FD3S+RD3S+TD3S	+FD3W+RD3W+TD3W			3	5	4	
20	+FD4H+RD4H+TD4H	+FD4S+RD4S+TD4S	+FD4W+RD4W+TD4W			5	8	8	
21									
22	Annual Average =		@AVG(P17..R20)						
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33	E1141	E1142	E1143	E1211	E1212	E1213	E1221	E1222	E1223
34	----------	----------	----------	----------	----------	----------	----------	----------	----------
35									
36	322	537	315	0	0	0	0	0	144
37	3.52	3.36	3.29	0	0	0	0	0	2.2
38	+$OFC1H*$CRA4	+$OFC1S*$CRA4	+$OFC1W*$CRA4	+$OFC1H*$C	+$OFC1S*$C	+$OFC1W*$C	+$OFC1H*$C	+$OFC1S*$C	+$OFC1W*$C
39	0	0	0	0	0	0	0	0	0
40									
41									
42	(P36*P37)-(P38+	(Q36*Q37)-(Q38+	(R36*R37)-(R38+	(S36*S37)-	(T36*T37)-	(U36*U37)-	(V36*V37)-	(W36*W37)-	(X36*X37)-
43									
44									
45									
46	0	0	0	0	0	0	0	0	0
47									
48	+$FLT1*P49*$PT1	+$FLT1*Q49*$PT1	+$FLT1*R49*$PT1	+$FLT1*S49	+$FLT1*T49	+$FLT1*U49	+$FLT1*V49	+$FLT1*W49	+$FLT1*X49
49	(FD1H*(ARDF1/RD	(FD1S*(ARDF1/RD	(FD1W*(ARDF1/RD	(FD1H*(ARD	(FD1S*(ARD	(FD1W*(ARD	(FD1H*(ARD	(FD1S*(ARD	(FD1W*(ARD
50									

A	Y	Z	AA	AB	AC
2					
3					
4					
5					
6		FISHING DAYS PER TRIP			
7		(ANNUAL AVERAGE) [AFDFi]			
8		14			
9		10			
10		14			
11		14			
12					
13					
14			AVERAGE (PER TRIP)		
15			FISHING DAYS [FDii]		
16		Holiday	Summer	Winter	
17		+AFDF1*Z22	+AFDF1*AA22	+AFDF1*AB22	
18		+AFDF2*Z22	+AFDF2*AA22	+AFDF2*AB22	
19		+AFDF3*Z22	+AFDF3*AA22	+AFDF3*AB22	
20		+AFDF4*Z22	+AFDF4*AA22	+AFDF4*AB22	
21					
22	RATE =	1	1.5	0.75	
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33	E1231	E1232	E1233	E1241	E1242
34	----------	----------	----------	----------	----------
35				77.86516853	
36	272	300	394	899	1145
37	3	1.76	1.69	2.04	1.3
38	+$OPC1H*$C	+$OPC1S*$CR	+$OPC1W*$CR	+$OPC1H*$CR	+$OPC1S*$C
39	0	0	0	0	0
40					
41					
42	(Y36*Y37)-	(Z36*Z37)-(	(AA36*AA37)	(AB36*AB37)	(AC36*AC37
43					
44					
45					
46	0	0	0	0	0
47					
48	+$FLT1*Y49	+$FLT1*Z49*	+$FLT1*AA49	+$FLT1*AB49	+$FLT1*AC4
49	(FD1H*(ARD	(FD1S*(ARDF	(FD1W*(ARDF	(FD1H*(ARDF	(FD1S*(ARD
50					

A	AD	AE	AF	AG	AH	AI	AJ
2							
3							
4							
5							
6		RUNNING DAYS BY AREA PER TRIP [RDiAi]					
7	MHI	MAU	LOWER	UPPER	AVERAGE [ARDFi]		
8	2	5	6	8	@AVG(AD8..AG8)		
9	2	6	7	-	@AVG(AD9..AF9)		
10	2	5	6	8	@AVG(AD10..AG10)		
11	2	7	8	10	@AVG(AD11..AG11)		
12	@AVG(AD8..AD11)	@AVG(AE8..AE11)	@AVG(AF8..AF11)	@SUM(AG8..AG11)	@AVG(AH8..AH11)		
13							
14			AVERAGE (PER TRIP)				
15			RUNNING DAYS [RDii]				
16		Holiday	Summer	Winter			
17		+ARDF1*SRDSH	+ARDF1*SRDSS	+ARDF1*SRDSW			
18		+ARDF2*SRDSH	+ARDF2*SRDSS	+ARDF2*SRDSW			
19		+ARDF3*SRDSH	+ARDF3*SRDSS	+ARDF3*SRDSW			
20		+ARDF4*SRDSH	+ARDF4*SRDSS	+ARDF4*SRDSW			
21							
22	RATE =	1	0.75	1.25			
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33	E1243	E1311	E1312	E1313	E1321	E1322	E1323
34	--------------	--------------	--------------	--------------	--------------	--------------	--------------
35				538.39762611		505.052192	
36	825	0	0	1412	0	377	1289
37	1.4	0	0	2.38	0	1.5	1.74
38	+SOFC1W*SCRA4	+SOFC1H*SCRA1	+SOFC1S*SCRA1	+SOFC1W*SCRA1	+SOFC1H*SCRA2	+SOFC1S*SC	+SOFC1W*SC
39	0	0	0	0	0	0	0
40							
41							
42	(AD36*AD37)-(AD	(AE36*AE37)-(AE	(AF36*AF37)-(AF	(AG36*AG37)-(AG	(AH36*AH37)-(AH3	(AI36*AI37	(AJ36*AJ37
43							
44							
45							
46	0	0	0	0	0	0	0
47							
48	+SFLT1*AD49*SPT	+SFLT1*AE49*SPT	+SFLT1*AF49*SPT	+SFLT1*AG49*SPT	+SFLT1*AH49*SPT1	+SFLT1*AI4	+SFLT1*AJ4
49	(FD1W*(ARDF1/RD	+SFD1H*(SARDF1/	+SFD1S*(SARDF1/	+SFD1W*(SARDF1/	+SFD1H*(SARDF1/S	+SFD1S*(SA	+SFD1W*(SA
50							

A	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT
2										
3										
4										
5										
6	POTENTIAL TRIPS [PTii]					ANNUAL FIXED COSTS [FCVi]				
7		PER SEASON				(PER VESSEL)				
8	Holiday	Summer	Winter			75000				
9	($SEAH/OD1H)	($SEAS/OD1S)	($SEAW/OD1W)			60000				
10	($SEAH/OD2H)	($SEAS/OD2S)	($SEAW/OD2W)			75000				
11	($SEAH/OD3H)	($SEAS/OD3S)	($SEAW/OD3W)			50000				
12	($SEAH/OD4H)	($SEAS/OD4S)	($SEAW/OD4W)							
13										
14										
15	ACTUAL TRIPS (PER BOAT)					AVERAGE (PER DAY)			AREA COST	
16		PER SEASON				OPERATING COSTS [OFCii]			RATIO [CRAi]	
17	Holiday	Summer	Winter		Holiday	Summer	Winter			
18	+G25/FD1H	+H25/FD1S	+I25/FD1W		250	200	225		AREA 1 = +R22/(R22-AD12)	
19	+G26/FD2H	+H26/FD2S	+I26/FD2W		200	150	175		AREA 2 = +R22/(R22-AE12)	
20	+G27/FD3H	+H27/FD3S	+I27/FD3W		250	200	225		AREA 3 = +R22/(R22-AF12)	
21	+G28/FD4H	+H28/FD4S	+I28/FD4W		225	175	200		AREA 4 = +R22/(R22-AG12)	
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33	E1331	E1332	E1333	E1341	E1342	E1343	E2111	E2112	E2113	E2121
34	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
35				148.651685						
36	7	189	126	1108	164	309	83	27	23	0
37	3.43	1.96	2.27	2.17	1.95	2.18	5.04	3.89	3.45	0
38	+$OFC1H*$CRA	+$OFC1S*$CRA	+$OFC1W*$CRA	+$OFC1H*$C	+$OFC1S*$C	+$OFC1W*$C	+$OFC2H*$C	+$OFC2S*$C	+$OFC2W*$C	+$OFC2H*$CRA2
39	0	0	0	0	0	0	0	0	0	0
40										
41										
42	(AK36*AK37)-	(AL36*AL37)-	(AM36*AM37)-	(AN36*AN37	(AO36*AO37	(AP36*AP37	(AQ36*AQ37	(AR36*AR37	(AS36*AS37	(AT36*AT37)-(AT
43										
44										
45										
46	0	0	0	0	0	0	0	0	0	0
47										
48	+$FLT1*AK49*	+$FLT1*AL49*	+$FLT1*AM49*	+$FLT1*AN4	+$FLT1*AO4	+$FLT1*AP4	+$FLT2*AQ4	+$FLT2*AR4	+$FLT2*AS4	+$FLT2*AT49*$PT
49	+$FD1H*($ARD	+$FD1S*($ARD	+$FD1W*($ARD	+$FD1H*($A	+$FD1S*($A	+$FD1W*($A	+$FD2H*($A	+$FD2S*($A	+$FD2W*($A	+$FD2H*($ARDF2/
50										

A	EK	EL	EM	EN	EO	EP	EQ
27							
28							
29							
30							
31							
32							
33	E4343	K1---	K2---	K3---	K4---	NET PROFIT	
34	------------------------	------------------------	------------------------	------------------------	------------------------	------------------------	
35		6	3	7.5	4	4778096.76	
36	112						
37	2.7						
38	+SOFC4W*SCRA4						
39	0	+FCV1	+FCV2	+FCV3	+FCV4		
40							
41							
42	(EK36*EK37)-(EK38+EK39)	(EL36*EL37)-(EL38+EL39)	(EM36*EM37)-(EM38+EM39)	(EN36*EN37)-(EN38+EN39)	(EO36*EO37)-(EO38+EO39)		
43							
44							
45							
46	0	+SFLT01	+SFLT02	+SFLT03	+SFLT04		
47							
48	+SFLT4*EK49*SPT4W	+SFLT1	+SFLT2	+SFLT3	+SFLT4		
49	+SFD4W*(SARDF4/SRD4A4)						
50							
51							
52						<=	94000
53						<=	76200
54						<=	94400
55						<=	192400
56						<=	62750
57						<=	49800
58						<=	61600
59						<=	125600
60	+EKS36					<=	11000000
61		-SF1S1				<=	0
62		-SF1S2				<=	0
63		-SF1S3				<=	0
64			-SF2S1			<=	0
65			-SF2S2			<=	0
66			-SF2S3			<=	0
67				-SF3S1		<=	0
68				-SF3S2		<=	0
69				-SF3S3		<=	0
70					-SF4S1	<=	0
71					-SF4S2	<=	0
72	1				-SF4S3	<=	0
73							
74							
75							

APPENDIX - ITEM C3: RANGE NAME LISTING

NAME	LOCATION	
83CONSTRAINT	F52..EQ72	
83COST	G42..EO42	
83LOWER	G46..EO46	
83TITLE	H2	
83UPPER	G48..EO48	
83VA	G35..EO35	
83VARIABLE	G33..EO33	
AFDF1	Z8	
AFDF2	Z9	
AFDF3	Z10	) Average Fishing Days per trip for Fleet #
AFDF4	Z11	
ARDF1	AH8	
ARDF2	AH9	
ARDF3	AH10	) Average Running Days per trip for Fleet #
ARDF4	AH11	
CRA1	AT18	
CRA2	AT19	
CRA3	AT20	) Cost Ratio for Area #
CRA4	AT21	
F1S1	G17	
F1S2	H17	
F1S3	I17	
F2S1	G18	
F2S2	H18	
F2S3	I18	
F3S1	G19	) total potential fishing days for
F3S2	H19	) Fleet # in Season #
F3S3	I19	
F4S1	G20	
F4S2	H20	
F4S3	I20	
FCV1	AP8	
FCV2	AP9	) annual Fixed Costs per Vessel in fleet #
FCV3	AP10	
FCV4	AP11	

FD1H	Z17	
FD1S	AA17	
FD1W	AB17	
FD2H	Z18	
FD2S	AA18	
FD2W	AB18	
FD3H	Z19	) average Fishing Days for fleet #
FD3S	AA19	) in season "L"
FD3W	AB19	
FD4H	Z20	
FD4S	AA20	
FD4W	AB20	
FLT01	G7	
FLT02	G8	) minimum number of vessels in FLeeT #
FLT03	G9	
FLT04	G10	
FLT1	H7	
FLT2	H8	) maximum number of vessels in FLeeT #
FLT3	H9	
FLT4	H10	
OD1H	P17	
OD1S	Q17	
OD1W	R17	
OD2H	P18	
OD2S	Q18	
OD2W	R18	) average Operating Days for fleet #
OD3H	P19	) in season "L"
OD3S	Q19	
OD3W	R19	
OD4H	P20	
OD4S	Q20	
OD4W	R20	
OF1S1	K17	
OF1S2	L17	
OF1S3	M17	
OF2S1	K18	
OF2S2	L18	
OF2S3	M18	) total potential Operating days for Fleet #
OF3S1	K19	) in Season #
OF3S2	L19	
OF3S3	M19	
OF4S1	K20	
OF4S2	L20	
OF4S3	M20	

APPENDIX D

APPENDIX - ITEM D1: BTM1 SPREADSHEET - DISTRIBUTED q AND p

A	B	C	D	E	F	G	H	I
2	BTM1.WKS		** TITLE SECTION **				NWHI Bottomfish Model	
3	08-Dec-88							
4			** OPERATING ENVIRONMENT SECTION **					
5								
6					FLEET SIZE	MINIMUM	MAXIMUM	
7				FLEET 1 =	Large Multipur	3	6	
8				FLEET 2 =	Medium Multipur	1.5	3	
9				FLEET 3 =	Tuna Longline	7.5	15	
10				FLEET 4 =	Motor-Sailers	2	4	
11						Minimum =	0.5	
12								
13								
14						TOTAL POTENTIAL FISHING		
15						DAYS PER BOAT PER SEASON [FiSi]		
16					SEASON	1=Holiday	2=Summer	3=Winter
17					Large Multipur	38	84	90
18					Medium Multipur	30	67	62
19					Tuna Longline	38	84	90
20					Motor-Sailers	33	74	70
21								
22								
23						ACTUAL FISHING DAYS (PER BOAT)		
24						Holiday	Summer	Winter
25						37.8	84.2	89.7
26						30.0	67.3	62.1
27						37.8	84.2	89.7
28						32.6	74.0	70.2
29								
30								
31								
32				LP83 DATA SECTION (Fishing Day basis)				
33					VARIABLE LIST->	E1111	E1112	E1113
34				** ECONOMIC PARAMETERS		----------	----------	----------
35				** SOLUTION VALUES				99
36				* DAILY CATCH RATE (q)		180	230	241
37				* FISH PRICE (p)		3.66	2.35	2.88
38				* DAILY OPERATING COST (c)		272	217	244
39				* ANNUAL FIXED COST/VESSEL		0	0	0
40				*				
41			** OBJECTIVE FUNCTION - MAX FLEETWIDE PROFIT *******					
42						387	322	449
43								
44			** BOUNDS ****************			Effort Level Bounds (Based on Cal		
45					Fishing Days			
46				* LOWER BOUNDS		0	0	0
47								
48				* UPPER BOUNDS		595	1326	1413
49			Fishing Days by Fleet,Area,Season			37	55	28

A	J	K	L	M	N	O	P	Q	R	S
2	- Version 1									
3										
4										
5										
6	SPECIES					FISHING AREAS			SEASONS	
7	SPECIES 1 = OPAKA,ONAGA				AREA 1 = Main Hawaiian Islands (to 161°)				Holiday =	1
8	SPECIES 2 = ALL OTHER BOTTOMFISH				AREA 2 = Mau (161°-165°)				Summer =	2
9	SPECIES 3 = ALL PELAGICS				AREA 3 = Lower Hoomalu (165°-170°)				Winter =	3
10					AREA 4 = Upper Hoomalu (170°-180°)					
11										
12										
13										
14			TOTAL POTENTIAL					AVERAGE (PER TRIP)		
15			OPERATING DAYS PER SEASON [OFiSi]					OPERATING DAYS [ODii]		
16		Holiday	Summer	Winter			Holiday	Summer	Winter	
17		60	120	180			22.3	29.9	21.1	
18		60	120	180			20.0	26.8	21.8	
19		60	120	180			22.3	29.9	21.1	
20		60	120	180			25.8	34.1	26.9	
21										
22							Annual Average =		25.1	
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33	E1121	E1122	E1123	E1131	E1132	E1133	E1141	E1142	E1143	E1211
34	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
35							1			
36	83	106	110	109	92	110	255	212	206	276
37	4.53	3.32	3.08	4.40	3.56	3.09	3.85	3.08	3.05	1.88
38	324	259	292	342	273	308	381	305	343	272
39	0	0	0	0	0	0	0	0	0	0
40										
41										
42	53	92	47	137	55	32	599	346	284	248
43										
44	endar Constraints)									
45										
46	0	0	0	0	0	0	0	0	0	0
47										
48	238	530	565	198	442	471	149	331	353	595
49	15	22	11	12	18	9	9	14	7	37
50										

A	T	U	V	W	X	Y	Z	AA	AB	AC
2										
3										
4										
5										
6		CALENDAR DAYS PER SEASON				FISHING DAYS PER TRIP				
7		60	120	180		(ANNUAL AVERAGE) [AFDFi]				
8		Dec-Jan=1	May-Aug=2	Feb-Apr			14			
9				Sept-Nov=3			10			
10							14			
11							14			
12										
13										
14			AVERAGE (PER TRIP)					AVERAGE (PER TRIP)		
15			TURN-AROUND DAYS [TDii]					FISHING DAYS [FDii]		
16		Holiday	Summer	Winter			Holiday	Summer	Winter	
17		3	5	4			14.0	21.0	10.5	
18		5	8	8			10.0	15.0	7.5	
19		3	5	4			14.0	21.0	10.5	
20		5	8	8			14.0	21.0	10.5	
21										
22						RATE =	1.00	1.50	0.75	
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33	E1212	E1213	E1221	E1222	E1223	E1231	E1232	E1233	E1241	E1242
34	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
35		170							112	253
36	352	369	128	162	168	167	142	168	391	324
37	1.21	1.48	2.33	1.71	1.59	2.26	1.83	1.59	1.98	1.58
38	217	244	324	259	292	342	273	308	381	305
39	0	0	0	0	0	0	0	0	0	0
40										
41										
42	208	302	-27	18	-25	36	-15	-40	391	208
43										
44										
45										
46	0	0	0	0	0	0	0	0	0	0
47										
48	1326	1413	238	530	565	198	442	471	149	331
49	55	28	15	22	11	12	18	9	9	14
50										

A	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM
2										
3										
4										
5										
6	RUNNING DAYS BY AREA PER TRIP [RDiAi]							POTENTIAL TRIPS [PTii]		
7	MHI	MAU	LOWER	UPPER	AVERAGE [ARDFi]				PER SEASON	
8	2	5	6	8	5.3			Holiday	Summer	Winter
9	2	6	7	-	5.0			2.7	4.0	8.5
10	2	5	6	8	5.3			3.0	4.5	8.3
11	2	7	8	10	6.8			2.7	4.0	8.5
12	2.0	5.8	6.8	8.7	5.6			2.3	3.5	6.7
13										
14			AVERAGE (PER TRIP)							
15			RUNNING DAYS [RDii]					ACTUAL TRIPS (PER BOAT)		
16		Holiday	Summer	Winter					PER SEASON	
17		5.3	3.9	6.6				Holiday	Summer	Winter
18		5.0	3.8	6.3				2.7	4.0	8.5
19		5.3	3.9	6.6				3.0	4.5	8.3
20		6.8	5.1	8.4				2.7	4.0	8.5
21								2.3	3.5	6.7
22	RATE =	1.00	0.75	1.25						
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33	E1243	E1311	E1312	E1313	E1321	E1322	E1323	E1331	E1332	E1333
34	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
35										
36	315	98	125	131	45	58	60	59	50	60
37	1.57	2.48	1.60	1.96	3.08	2.26	2.09	2.99	2.42	2.10
38	343	272	217	244	324	259	292	342	273	308
39	0	0	0	0	0	0	0	0	0	0
40										
41										
42	151	-28	-18	12	-185	-129	-166	-165	-152	-182
43										
44										
45										
46	0	0	0	0	0	0	0	0	0	0
47										
48	353	595	1326	1413	238	530	565	198	442	471
49	7	37	55	28	15	22	11	12	18	9
50										

A	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW
2										
3										
4										
5										
6			ANNUAL FIXED COSTS [FCVi]							
7			(PER VESSEL)							
8			75000							
9			60000							
10			75000							
11			50000							
12										
13										
14										
15			AVERAGE (PER DAY)			AREA COST				
16			OPERATING COSTS [OPCii]			RATIO [CRAi]				
17		Holiday	Summer	Winter						
18		250	200	225		AREA 1 =	1.09			
19		200	150	175		AREA 2 =	1.30			
20		250	200	225		AREA 3 =	1.37			
21		225	175	200		AREA 4 =	1.53			
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33	E1341	E1342	E1343	E2111	E2112	E2113	E2121	E2122	E2123	E2131
34	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
35										
36	139	115	112	21	26	28	10	12	13	12
37	2.61	2.09	2.07	4.93	3.17	3.89	6.11	4.48	4.16	5.93
38	381	305	343	217	163	190	259	194	227	273
39	0	0	0	0	0	0	0	0	0	0
40										
41										
42	-19	-64	-112	-115	-80	-83	-201	-140	-174	-199
43										
44										
45										
46	0	0	0	0	0	0	0	0	0	0
47										
48	149	331	353	225	505	466	75	168	155	64
49	9	14	7	25	38	19	8	13	6	7
50										

	A	B	C	D	E	F	G	H	I	J
50				** CONSTRAINTS ****************						
51										
52					* Q LIMITS	Q-11-	180.165345	229.576530	240.536396	
53						Q-12-				83.3220841
54						Q-13-				
55						Q-14-				
56						Q-21-				
57						Q-22-				
58						Q-23-				
59						Q-24-				
60						Q-3--				
61					* E LIMITS	E1--1	1			1
62						E1--2		1		
63						E1--3			1	
64						E2--1				
65						E2--2				
66						E2--3				
67						E3--1				
68						E3--2				
69						E3--3				
70						E4--1				
71						E4--2				
72						E4--3				
73										
74										
75										

A	EH	EI	EJ	EK	EL	EM	EN	EO	EP	EQ
28										
29										
30										
31										
32										
33	E4333	E4341	E4342	E4343	K1---	K2---	K3---	K4---	NET PROFIT	
34	----------	----------	----------	----------	----------	----------	----------	----------	----------	
35					3	1.5	15	4	2083444.04	
36	43	100	83	81						
37	2.29	2.85	2.28	2.26						
38	273	343	267	305						
39	0	0	0	0	75000	60000	75000	50000		
40										
41										
42	-174	-58	-77	-123	-75000	-60000	-75000	-50000		
43										
44										
45										
46	0	0	0	0	3	1.5	7.5	2		
47										
48	237	88	200	189	6	3	15	4		
49	9	9	14	7						
50										
51										
52									<=	94000
53									<=	76200
54									<=	94400
55									<=	192400
56									<=	62750
57									<=	49800
58									<=	61600
59									<=	125600
60	43.1794493	100.133915	83.1404943	80.8270593					<=	11000000
61					-38				<=	0
62					-84				<=	0
63					-90				<=	0
64						-30			<=	0
65						-67			<=	0
66						-62			<=	0
67							-38		<=	0
68							-84		<=	0
69							-90		<=	0
70		1						-33	<=	0
71			1					-74	<=	0
72	1			1				-70	<=	0
73										
74										
75										

APPENDIX - ITEM D2: CATCH RATE AND PRICE TABLES

FL_SP CATCH RATE TABLE - q

	Sp-1	Sp-2	Sp-3
Flt-1	177	271	96
Flt-2	20	56	121
Flt-3	149	144	381
Flt-4	356	292	69

AREA_SEAS CATCH RATE TABLE - q

	Sea-1	Sea-2	Sea-3
Area-1	213	271	284
Area-2	98	125	130
Area-3	129	109	130
Area-4	301	250	243

TOTAL AVERAGE CATCH RATE

ALL-q	208
Std	248
COVq=	1.19

VARIABLE	E1111	E1112	E1113	E1121	E1122	E1123	E1131	E1132	E1133	E1141	E1142	E1143	E1211	E1212
CATCH (q)	180	230	241	83	106	110	109	92	110	255	212	206	276	352
CATCH2 q	360	459	481	167	212	220	218	185	220	510	423	411	552	704

[range name = CQ (cells B21..EF21)]

[range name = CQ2 (cells B25..EF25)]

FL_SP PRICE TABLE - p

	Sp-1	Sp-2	Sp-3
Flt-1	3.22	1.66	2.19
Flt-2	4.35	2.63	2.86
Flt-3	3.49	1.71	2.44
Flt-4	3.35	1.45	2.39

AREA-SEAS PRICE TABLE - p

	Sea-1	Sea-2	Sea-3
Area-1	2.77	1.78	2.18
Area-2	3.43	2.51	2.33
Area-3	3.33	2.69	2.34
Area-4	2.91	2.33	2.31

TOTAL AVERAGE PRICE

ALL-p =	2.44
Std =	1.12
COVp =	0.46

VARIABLE	E1111	E1112	E1113	E1121	E1122	E1123	E1131	E1132	E1133	E1141	E1142	E1143	E1211	E1212
PRICE (p)	3.66	2.35	2.88	4.53	3.32	3.08	4.40	3.56	3.09	3.85	3.08	3.05	1.88	1.21
PRICE2 p	5.48	3.52	4.33	6.79	4.98	4.62	6.60	5.33	4.64	5.77	4.62	4.57	2.82	1.81

[range name = PR (cells B47..EF47)]

[range name = PR2 (cells B51..EF51)]

APPENDIX - ITEM D3: LP83 REPORT FROM BTM1 RUN

```
LP83 BTM1.WKS OUTPUT C:PBT1 MAXIMIZE YES COSTANALYSIS YES
     MARGINANALYSIS YES

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                      Honolulu, Hawaii

  (83TITLE)
     Title: NWHI Bottomfish Model - Version 1

  (83VARIABLE)
  (83COST)
     Objective: MAXIMIZED Variables:   139
        387.0950 E1111
        322.1040 E1112
        449.2374 E1113
         53.3228 E1121
         92.1855 E1122
         47.1151 E1123
        137.1340 E1131
         55.0935 E1132
         32.3370 E1133
        599.3365 E1141
        346.2203 E1142
        283.6461 E1143
        247.5002 E1211
        207.7944 E1212
        302.2290 E1213
        -26.6657 E1221
         17.6986 E1222
        -24.6890 E1223
         35.6499 E1231
        -14.5197 E1232
        -39.6957 E1233
        391.4765 E1241
        208.1712 E1242
        150.7736 E1243
        -28.0668 E1311
        -17.8585 E1312
         12.0271 E1313
       -184.5669 E1321
       -129.3422 E1322
       -166.4339 E1323
       -164.6848 E1331
       -151.9398 E1332
       -181.8920 E1333
        -18.8493 E1341
        -64.3446 E1342
       -111.5234 E1343
       -115.3658 E2111
        -79.5056 E2112
        -82.7930 E2113
       -200.8928 E2121
       -140.0866 E2122
       -174.4567 E2123
       -199.2942 E2131
       -154.2161 E2132
       -186.6229 E2133
        -46.0458 E2211
        -22.7418 E2212
         -9.7916 E2213
       -161.1721 E2221
       -103.0979 E2222
       -138.8002 E2223
       -148.8993 E2231
       -119.6476 E2232
       -150.8529 E2233
        181.8826 E2311
        163.9014 E2312
        230.2417 E2313
        -30.5680 E2321
         18.5232 E2322
        -21.5594 E2323
         16.8026 E2331
         -5.9840 E2332
```

-33.2388	E2333
330.6795	E3111
275.9072	E3112
389.8258	E3113
20.9964	E3121
62.0826	E3122
18.0963	E3123
96.1205	E3131
26.9602	E3132
3.2259	E3133
515.3325	E3141
290.4294	E3142
229.9473	E3143
14.1483	E3211
16.7100	E3212
56.4842	E3213
-160.3775	E3221
-106.8165	E3222
-144.7195	E3223
-133.9948	E3231
-130.8879	E3232
-160.1084	E3233
44.0100	E3241
-22.5969	E3242
-71.3412	E3243
802.1874	E3311
662.0097	E3312
886.3745	E3313
291.1727	E3321
313.6762	E3322
260.6283	E3323
438.9023	E3331
262.0921	E3332
246.5302	E3333
1,217.4188	E3341
756.7164	E3342
678.7495	E3343
1,134.1302	E4111
938.7465	E4112
1,234.5037	E4113
498.2259	E4121
508.7176	E4122
449.8123	E4123
694.6496	E4131
448.2546	E4132
437.9753	E4133
1,709.3951	E4141
1,096.2721	E4142
1,007.0031	E4143
247.4538	E4211
212.6759	E4212
300.7376	E4213
-9.8439	E4221
35.5927	E4222
-6.2721	E4223
50.0442	E4231
6.0861	E4232
-19.5615	E4233
389.1131	E4241
219.4137	E4242
163.0250	E4243
-52.5307	E4311
-32.9716	E4312
-15.1785	E4313
-181.7364	E4321
-124.4771	E4322
-160.5767	E4323
-168.0418	E4331
-143.5105	E4332
-174.3575	E4333
-57.5709	E4341
-77.2492	E4342
-122.5137	E4343
-75000.0000	K1---
-60000.0000	K2---
-75000.0000	K3---
-50000.0000	K4---

(83LOWER)
(83UPPER)

Lower & Upper Bounds

0.0000	<=	E1111	<=	594.6067
0.0000	<=	E1112	<=	1,325.7620
0.0000	<=	E1113	<=	1,413.2938
0.0000	<=	E1121	<=	237.8427
0.0000	<=	E1122	<=	530.3048
0.0000	<=	E1123	<=	565.3175
0.0000	<=	E1131	<=	198.2022
0.0000	<=	E1132	<=	441.9207
0.0000	<=	E1133	<=	471.0979
0.0000	<=	E1211	<=	594.6067
0.0000	<=	E1212	<=	1,325.7620
0.0000	<=	E1213	<=	1,413.2938
0.0000	<=	E1221	<=	237.8427
0.0000	<=	E1222	<=	530.3048
0.0000	<=	E1223	<=	565.3175
0.0000	<=	E1231	<=	198.2022
0.0000	<=	E1232	<=	441.9207
0.0000	<=	E1233	<=	471.0979

0.0000	<=	E1141	<=	148.6517
0.0000	<=	E1142	<=	331.4405
0.0000	<=	E1143	<=	353.3234
0.0000	<=	E1311	<=	594.6067
0.0000	<=	E1312	<=	1,325.7620
0.0000	<=	E1313	<=	1,413.2938
0.0000	<=	E1321	<=	237.8427
0.0000	<=	E1322	<=	530.3048
0.0000	<=	E1323	<=	565.3175
0.0000	<=	E1331	<=	198.2022
0.0000	<=	E1332	<=	441.9207
0.0000	<=	E1333	<=	471.0979
0.0000	<=	E1341	<=	148.6517
0.0000	<=	E1342	<=	331.4405
0.0000	<=	E1343	<=	353.3234
0.0000	<=	E2111	<=	225.0000
0.0000	<=	E2112	<=	504.6729
0.0000	<=	E2113	<=	465.5172
0.0000	<=	E2121	<=	75.0000
0.0000	<=	E2122	<=	168.2243
0.0000	<=	E2123	<=	155.1724
0.0000	<=	E2131	<=	64.2857
0.0000	<=	E2132	<=	144.1923
0.0000	<=	E2133	<=	133.0049
0.0000	<=	E2211	<=	225.0000
0.0000	<=	E2212	<=	504.6729
0.0000	<=	E2213	<=	465.5172
0.0000	<=	E2221	<=	75.0000
0.0000	<=	E2222	<=	168.2243
0.0000	<=	E2223	<=	155.1724
0.0000	<=	E2231	<=	64.2857
0.0000	<=	E2232	<=	144.1923
0.0000	<=	E2233	<=	133.0049
0.0000	<=	E2311	<=	225.0000
0.0000	<=	E2312	<=	504.6729
0.0000	<=	E2313	<=	465.5172
0.0000	<=	E2321	<=	75.0000
0.0000	<=	E2322	<=	168.2243
0.0000	<=	E2323	<=	155.1724
0.0000	<=	E2331	<=	64.2857
0.0000	<=	E2332	<=	144.1923
0.0000	<=	E2333	<=	133.0049
0.0000	<=	E3111	<=	1,486.5169
0.0000	<=	E3112	<=	3,314.4050
0.0000	<=	E3113	<=	3,533.2344
0.0000	<=	E3121	<=	594.6067
0.0000	<=	E3122	<=	1,325.7620
0.0000	<=	E3123	<=	1,413.2938
0.0000	<=	E3131	<=	495.5056
0.0000	<=	E3132	<=	1,104.8017
0.0000	<=	E3133	<=	1,177.7448
0.0000	<=	E3141	<=	371.6292
0.0000	<=	E1241	<=	148.6517
0.0000	<=	E1242	<=	331.4405
0.0000	<=	E1243	<=	353.3234
0.0000	<=	E3222	<=	1,325.7620
0.0000	<=	E3223	<=	1,413.2938
0.0000	<=	E3231	<=	495.5056
0.0000	<=	E3232	<=	1,104.8017
0.0000	<=	E3233	<=	1,177.7448
0.0000	<=	E3241	<=	371.6292
0.0000	<=	E3242	<=	828.6013
0.0000	<=	E3243	<=	883.3086
0.0000	<=	E3311	<=	1,486.5169
0.0000	<=	E3312	<=	3,314.4050
0.0000	<=	E3313	<=	3,533.2344
0.0000	<=	E3321	<=	594.6067
0.0000	<=	E3322	<=	1,325.7620
0.0000	<=	E3323	<=	1,413.2938
0.0000	<=	E3331	<=	495.5056
0.0000	<=	E3332	<=	1,104.8017
0.0000	<=	E3333	<=	1,177.7448
0.0000	<=	E3341	<=	371.6292
0.0000	<=	E3342	<=	828.6013
0.0000	<=	E3343	<=	883.3086
0.0000	<=	E4111	<=	440.3883
0.0000	<=	E4112	<=	998.7523
0.0000	<=	E4113	<=	947.1926
0.0000	<=	E4121	<=	125.8252
0.0000	<=	E4122	<=	285.3578
0.0000	<=	E4123	<=	270.6265
0.0000	<=	E4131	<=	110.0971
0.0000	<=	E4132	<=	249.6881
0.0000	<=	E4133	<=	236.7981
0.0000	<=	E4141	<=	88.0777
0.0000	<=	E4142	<=	199.7505
0.0000	<=	E4143	<=	189.4385
0.0000	<=	E4211	<=	440.3883
0.0000	<=	E4212	<=	998.7523
0.0000	<=	E4213	<=	947.1926
0.0000	<=	E4221	<=	125.8252
0.0000	<=	E4222	<=	285.3578
0.0000	<=	E4223	<=	270.6265
0.0000	<=	E4231	<=	110.0971
0.0000	<=	E4232	<=	249.6881
0.0000	<=	E4233	<=	236.7981
0.0000	<=	E4241	<=	88.0777
0.0000	<=	E4242	<=	199.7505
0.0000	<=	E4243	<=	189.4385
0.0000	<=	E4311	<=	440.3883
0.0000	<=	E4312	<=	998.7523
0.0000	<=	E4313	<=	947.1926
0.0000	<=	E4321	<=	125.8252
0.0000	<=	E4322	<=	285.3578

0.0000	<=	E3142	<=	828.6013
0.0000	<=	E3143	<=	883.3086
0.0000	<=	E3211	<=	1,486.5169
0.0000	<=	E3212	<=	3,314.4050
0.0000	<=	E3213	<=	3,533.2344
0.0000	<=	E3221	<=	594.6067
3.0000	<=	K1---	<=	6.0000
1.5000	<=	K2---	<=	3.0000
7.5000	<=	K3---	<=	15.0000
2.0000	<=	K4---	<=	4.0000
0.0000	<=	E4323	<=	270.6265
0.0000	<=	E4331	<=	110.0971
0.0000	<=	E4332	<=	249.6881
0.0000	<=	E4333	<=	236.7981
0.0000	<=	E4341	<=	88.0777
0.0000	<=	E4342	<=	199.7505
0.0000	<=	E4343	<=	189.4385

(83CONSTRAINT)

Row: Q-11- Elements: 12

```
180.1653 E1111
229.5765 E1112
240.5364 E1113
 20.6756 E2111
 26.3460 E2112
 27.6037 E2113
152.3393 E3111
194.1191 E3112
203.3862 E3113
362.9421 E4111
462.4807 E4112
484.5593 E4113 <=94,000.0000
```

Row: Q-12- Elements: 12

```
 83.3221 E1121
105.8389 E1122
109.8937 E1123
  9.5620 E2121
 12.1460 E2122
 12.6113 E2123
 70.4532 E3121
 89.4924 E3122
 92.9209 E3123
167.8519 E4121
213.2119 E4122
221.3802 E4123 <=76,200.0000
```

Row: Q-13- Elements: 12

```
108.8808 E1131
 92.3632 E1132
109.8926 E1133
 12.4951 E2131
 10.5995 E2132
 12.6112 E2133
 92.0645 E3131
 78.0980 E3132
 92.9200 E3133
219.3398 E4131
186.0651 E4132
221.3780 E4133 <=94,400.0000
```

Row: Q-14- Elements: 9

```
254.8429 E1141
211.5943 E1142
205.7065 E1143
215.4831 E3141
178.9142 E3142
173.9358 E3143
513.3796 E4141
426.2555 E4142
414.3947 E4143 <=192400.0000
```

Row: Q-21- Elements: 12
276.1312 E1211
351.8615 E1212
368.6592 E1213
57.4630 E2211
73.2226 E2212
76.7182 E2213
147.0496 E3211
187.3786 E3212
196.3239 E3213
298.5243 E4211
380.3960 E4212
398.5559 E4213 <=62,750.0000

Row: Q-22- Elements: 12
127.7040 E1221
162.2144 E1222
168.4290 E1223
26.5753 E2221
33.7569 E2222
35.0502 E2223
68.0068 E3221
86.3849 E3222
89.6944 E3223
138.0602 E4221
175.3694 E4222
182.0879 E4223 <=49,800.0000

Row: Q-23- Elements: 12
166.8767 E1231
141.5608 E1232
168.4274 E1233
34.7271 E2231
29.4589 E2232
35.0498 E2233
88.8677 E3231
75.3861 E3232
89.6935 E3233
180.4097 E4231
153.0408 E4232
182.0861 E4233 <=61,600.0000

Row: Q-24- Elements: 9
390.5861 E1241
324.3009 E1242
315.2770 E1243
208.0008 E3241
172.7016 E3242
167.8961 E3243
422.2610 E4241
350.6003 E4242
340.8447 E4243 <=125600.0000

Row: Q-3-- Elements: 45
98.0809 E1311
124.9800 E1312
130.9465 E1313
45.3600 E1321
57.6180 E1322
59.8254 E1323
59.2740 E1331
50.2819 E1332
59.8248 E1333
138.7348 E1341
115.1906 E1342
111.9853 E1343
123.0687 E2311
156.8208 E2312
164.3074 E2313
56.9163 E2321
72.2972 E2322
75.0670 E2323
74.3751 E2331
63.0921 E2332
75.0662 E2333
388.7263 E3311
495.3363 E3312
518.9834 E3313
179.7765 E3321
228.3589 E3322
237.1076 E3323
234.9222 E3331
199.2836 E3332
237.1052 E3333
549.8513 E3341
456.5377 E3342
443.8342 E3343
70.7913 E4311
90.2062 E4312
94.5125 E4313
32.7393 E4321
41.5867 E4322
43.1799 E4323
42.7819 E4331
36.2917 E4332
43.1794 E4333
100.1339 E4341
83.1405 E4342
80.8271 E4343 <=11000000.00

Row: E1--1 Elements: 13
1.0000 E1111
1.0000 E1121
1.0000 E1131
1.0000 E1141
1.0000 E1211
1.0000 E1221
1.0000 E1231
1.0000 E1241
1.0000 E1311
1.0000 E1321
1.0000 E1331
1.0000 E1341
-37.7528 K1--- <= 0.0000

Row: E1--2 Elements: 13
1.0000 E1112
1.0000 E1122
1.0000 E1132
1.0000 E1142
1.0000 E1212
1.0000 E1222
1.0000 E1232
1.0000 E1242
1.0000 E1312
1.0000 E1322
1.0000 E1332
1.0000 E1342
-84.1754 K1--- <= 0.0000

Row: E1--3 Elements: 13
1.0000 E1113
1.0000 E1123
1.0000 E1133
1.0000 E1143
1.0000 E1213
1.0000 E1223
1.0000 E1233
1.0000 E1243
1.0000 E1313
1.0000 E1323
1.0000 E1333
1.0000 E1343
-89.7329 K1--- <= 0.0000

Row: E2--1 Elements: 10
1.0000 E2111
1.0000 E2121
1.0000 E2131
1.0000 E2211
1.0000 E2221
1.0000 E2231
1.0000 E2311
1.0000 E2321
1.0000 E2331
-30.0000 K2--- <= 0.0000

Row: E2--2 Elements: 10
1.0000 E2112
1.0000 E2122
1.0000 E2132
1.0000 E2212
1.0000 E2222
1.0000 E2232
1.0000 E2312
1.0000 E2322
1.0000 E2332
-67.2897 K2--- <= 0.0000

Row: E2--3 Elements: 10
1.0000 E2113
1.0000 E2123
1.0000 E2133
1.0000 E2213
1.0000 E2223
1.0000 E2233
1.0000 E2313
1.0000 E2323
1.0000 E2333
-62.0690 K2--- <= 0.0000

```
Row: E3--1    Elements:  13
        1.0000 E3111
        1.0000 E3121
        1.0000 E3131
        1.0000 E3141
        1.0000 E3211
        1.0000 E3221
        1.0000 E3231
        1.0000 E3241
        1.0000 E3311
        1.0000 E3321
        1.0000 E3331
        1.0000 E3341
      -37.7528 K3---  <= 0.0000
```

```
Row: E3--2    Elements:  13
        1.0000 E3112
        1.0000 E3122
        1.0000 E3132
        1.0000 E3142
        1.0000 E3212
        1.0000 E3222
        1.0000 E3232
        1.0000 E3242
        1.0000 E3312
        1.0000 E3322
        1.0000 E3332
        1.0000 E3342
      -84.1754 K3---  <= 0.0000
```

```
Row: E3--3    Elements:  13
        1.0000 E3113
        1.0000 E3123
        1.0000 E3133
        1.0000 E3143
        1.0000 E3213
        1.0000 E3223
        1.0000 E3233
        1.0000 E3243
        1.0000 E3313
        1.0000 E3323
        1.0000 E3333
        1.0000 E3343
      -89.7329 K3---  <= 0.0000
```

```
Row: E4--1    Elements:  13
        1.0000 E4111
        1.0000 E4121
        1.0000 E4131
        1.0000 E4141
        1.0000 E4211
        1.0000 E4221
        1.0000 E4231
        1.0000 E4241
        1.0000 E4311
        1.0000 E4321
        1.0000 E4331
        1.0000 E4341
      -32.6214 K4---  <= 0.0000
```

```
Row: E4--2    Elements:  13
        1.0000 E4112
        1.0000 E4122
        1.0000 E4132
        1.0000 E4142
        1.0000 E4212
        1.0000 E4222
        1.0000 E4232
        1.0000 E4242
        1.0000 E4312
        1.0000 E4322
        1.0000 E4332
        1.0000 E4342
      -73.9817 K4---  <= 0.0000
```

```
Row: E4--3    Elements:  13
        1.0000 E4113
        1.0000 E4123
        1.0000 E4133
        1.0000 E4143
        1.0000 E4213
        1.0000 E4223
        1.0000 E4233
        1.0000 E4243
        1.0000 E4313
        1.0000 E4323
        1.0000 E4333
        1.0000 E4343
      -70.1624 K4---  <= 0.0000
```

(83VA)
(83CA)
(83VR)
(83CR)

Statistics-
LP83 Version 5.00
Machine memory: 640K bytes.
Pagable memory: 411K bytes.
Variables: 139
Constraints: 21
21 LE, 0 EQ, 0 GE.
Non-zero LP elements: 282
Disk Space: 0K bytes.
Page Space: 23K bytes.
Capacity: 15.1% used.
Estimated Time: 00:01:43

Iter 25
Solution Time: 00:00:03
U n i q u e S o l u t i o n

File: BTM1 12/14/88 15:35:17 Page 1-1
SOLUTION (Maximized): 2083444.048 NWHI Bottomfish Model - Version 1

Variable	Activity	Cost	Variable	Activity	Cost
E1111	0.0000	387.0950	E1112	0.0000	322.1040
E1113	98.9874	449.2374	E1121	0.0000	53.3228
E1122	0.0000	92.1855	E1123	0.0000	47.1151
E1131	0.0000	137.1340	E1132	0.0000	55.0935
E1133	0.0000	32.3370	E1141	1.3611	599.3365
E1142	0.0000	346.2203	E1143	0.0000	283.6461
E1211	0.0000	247.5002	E1212	0.0000	207.7944
E1213	170.2114	302.2290	E1221	0.0000	-26.6657
E1222	0.0000	17.6986	E1223	0.0000	-24.6890
E1231	0.0000	35.6499	E1232	0.0000	-14.5197
E1233	0.0000	-39.6957	E1241	111.8974	391.4765

I	E1242	252.5261	208.1712	E1243	0.0000	150.7736
	E1311	0.0000	-28.0668	E1312	0.0000	-17.8585
	E1313	0.0000	12.0271	E1321	0.0000	-184.5669
	E1322	0.0000	-129.3422	E1323	0.0000	-166.4339
	E1331	0.0000	-164.6848	E1332	0.0000	-151.9398
	E1333	0.0000	-181.8920	E1341	0.0000	-18.8493
	E1342	0.0000	-64.3446	E1343	0.0000	-111.5234
	E2111	0.0000	-115.3658	E2112	0.0000	-79.5056
	E2113	0.0000	-82.7930	E2121	0.0000	-200.8928
	E2122	0.0000	-140.0866	E2123	0.0000	-174.4567
	E2131	0.0000	-199.2942	E2132	0.0000	-154.2161
	E2133	0.0000	-186.6229	E2211	0.0000	-46.0458
	E2212	0.0000	-22.7418	E2213	0.0000	-9.7916
	E2221	0.0000	-161.1721	E2222	0.0000	-103.0979
	E2223	0.0000	-138.8002	E2231	0.0000	-148.8993
	E2232	0.0000	-119.6476	E2233	0.0000	-150.8529
I	E2311	45.0000	181.8826 I	E2312	100.9346	163.9014
I	E2313	93.1034	230.2417	E2321	0.0000	-30.5680
	E2322	0.0000	18.5232	E2323	0.0000	-21.5594
	E2331	0.0000	16.8026	E2332	0.0000	-5.9840
	E2333	0.0000	-33.2388	E3111	0.0000	330.6795
	E3112	0.0000	275.9072	E3113	0.0000	389.8258
	E3121	0.0000	20.9964	E3122	0.0000	62.0826
	E3123	0.0000	18.0963	E3131	0.0000	96.1205
	E3132	0.0000	26.9602	E3133	0.0000	3.2259
	E3141	0.0000	515.3325	E3142	0.0000	290.4294

E3143	0.0000	229.9473	E3211	0.0000	14.1483
E3212	0.0000	16.7100	E3213	0.0000	56.4842
E3221	0.0000	-160.3775	E3222	0.0000	-106.8165
E3223	0.0000	-144.7195	E3231	0.0000	-133.9948
E3232	0.0000	-130.8879	E3233	0.0000	-160.1084
E3241	0.0000	44.0100	E3242	0.0000	-22.5969
E3243	0.0000	-71.3412	E3311	194.6629	802.1874
E3312	434.0292	662.0097	E3313	1,345.9941	886.3745
E3321	0.0000	291.1727	E3322	0.0000	313.6762
E3323	0.0000	260.6283	E3331	0.0000	438.9023
E3332	0.0000	262.0921	E3333	0.0000	246.5302
E3341	371.6292	1,217.4188	E3342	828.6013	756.7164
E3343	0.0000	678.7495	E4111	17.4548	1,134.1302
E4112	0.0000	938.7465	E4113	131.7792	1,234.5037
E4121	0.0000	498.2259	E4122	96.1761	508.7176
E4123	0.0000	449.8123	E4131	24.9530	694.6496
E4132	0.0000	448.2546	E4133	0.0000	437.9753
E4141	88.0777	1,709.3951	E4142	199.7505	1,096.2721
E4143	148.8704	1,007.0031	E4211	0.0000	247.4538
E4212	0.0000	212.6759	E4213	0.0000	300.7376
E4221	0.0000	-9.8439	E4222	0.0000	35.5927
E4223	0.0000	-6.2721	E4231	0.0000	50.0442
E4232	0.0000	6.0861	E4233	0.0000	-19.5615
E4241	0.0000	389.1131	E4242	0.0000	219.4137
E4243	0.0000	163.0250	E4311	0.0000	-52.5307
E4312	0.0000	-32.9716	E4313	0.0000	-15.1785

E4321	0.0000	-181.7364	E4322	0.0000	-124.4771
E4323	0.0000	-160.5767	E4331	0.0000	-168.0418
E4332	0.0000	-143.5105	E4333	0.0000	-174.3575
E4341	0.0000	-57.5709	E4342	0.0000	-77.2492
E4343	0.0000	-122.5137	K1---	3.0000	-75000.0000
K2---	1.5000	-60000.0000	K3---	15.0000	-75000.0000
K4---	4.0000	-50000.0000			

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CONSTRAINTS: NWHI Bottomfish Model - Version 1

Constraint	Activity	RHS	Constraint	Activity	RHS
Q-11-	94,000.0000	<94,000.0000	Q-12-	20,505.8968	<76,200.0000
Q-13-	5,473.1772	<94,400.0000	Q-14-	192400.0000	<192400.0000
Q-21-	62,750.0000	<62,750.0000	Q-22-	0.0000	<49,800.0000
Q-23-	0.0000	<61,600.0000	Q-24-	125600.0000	<125600.0000
Q-3--	1608502.457	<11000000.00	E1--1	0.0000 <	0.0000
E1--2	0.0000 <	0.0000	E1--3	0.0000 <	0.0000
E2--1	0.0000 <	0.0000	E2--2	0.0000 <	0.0000
E2--3	0.0000 <	0.0000	E3--1	0.0000 <	0.0000
E3--2	0.0000 <	0.0000	E3--3	0.0000 <	0.0000
E4--1	0.0000 <	0.0000	E4--2	0.0000 <	0.0000
E4--3	0.0000 <	0.0000			

Total Error: 0.000000

COST ANALYSIS: NWHI Bottomfish Model - Version 1

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	596.5691	<------	Upper	475.3124	<------
E1111	387.0950		E1112	322.1040	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		209.4741	Reduced Cost		153.2084
Upper	582.5182	E1212	Upper	378.4099	<------
E1113	449.2374		E1121	53.3228	
Lower	431.4878	E1243	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		325.0871
Upper	197.3221	<------	Upper	157.9759	<------
E1122	92.1855		E1123	47.1151	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		105.1365	Reduced Cost		110.8608
Upper	378.4099	<------	Upper	197.3221	<------
E1131	137.1340		E1132	55.0935	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		241.2759	Reduced Cost		142.2286
Upper	157.9759	<------	Upper	612.4031	Q-24-
E1133	32.3370		E1141	599.3365	
Lower	UNBOUNDED		Lower	557.7420	E1142
Reduced Cost		125.6389	Reduced Cost		0.0000
Upper	380.7558	<------	Upper	336.3055	<------
E1142	346.2203		E1143	283.6461	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		34.5356	Reduced Cost		52.6594
Upper	486.4576	<------	Upper	335.0024	<------
E1211	247.5002		E1212	207.7944	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		238.9574	Reduced Cost		127.2080
Upper	UNBOUNDED		Upper	378.4099	<------
E1213	302.2290		E1221	-26.6657	
Lower	168.9482	E1212	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		405.0756
Upper	197.3221	<------	Upper	157.9759	<------
E1222	17.6986		E1223	-24.6890	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		179.6234	Reduced Cost		182.6649

COST ANALYSIS: NWHI Bottomfish Model - Version 1

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	378.4099	<------	Upper	197.3221	<------
E1231	35.6499		E1232	-14.5197	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		342.7600	Reduced Cost		211.8418
Upper	157.9759	<------	Upper	433.0710	E1142
E1233	-39.6957		E1241	391.4765	
Lower	UNBOUNDED		Lower	378.4099	Q-24-
Reduced Cost		197.6717	Reduced Cost		0.0000
Upper	563.7225	K1---	Upper	168.5232	<------
E1242	208.1712		E1243	150.7736	
Lower	173.6356	E1142	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		17.7496
Upper	378.4099	<------	Upper	197.3221	<------
E1311	-28.0668		E1312	-17.8585	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		406.4767	Reduced Cost		215.1806
Upper	157.9759	<------	Upper	378.4099	<------
E1313	12.0271		E1321	-184.5669	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		145.9488	Reduced Cost		562.9769
Upper	197.3221	<------	Upper	157.9759	<------
E1322	-129.3422		E1323	-166.4339	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		326.6642	Reduced Cost		324.4098
Upper	378.4099	<------	Upper	197.3221	<------
E1331	-164.6848		E1332	-151.9398	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		543.0947	Reduced Cost		349.2618
Upper	157.9759	<------	Upper	378.4099	<------
E1333	-181.8920		E1341	-18.8493	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		339.8679	Reduced Cost		397.2592
Upper	197.3221	<------	Upper	157.9759	<------
E1342	-64.3446		E1343	-111.5234	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		261.6666	Reduced Cost		269.4993

COST ANALYSIS: NWHI Bottomfish Model - Version 1

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	206.9183	<------	Upper	195.8033	<------
E2111	-115.3658		E2112	-79.5056	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		322.2841	Reduced Cost		275.3090
Upper	263.6666	<------	Upper	181.8826	<------
E2113	-82.7930		E2121	-200.8928	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		346.4596	Reduced Cost		382.7753
Upper	163.9014	<------	Upper	230.2417	<------
E2122	-140.0866		E2123	-174.4567	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		303.9880	Reduced Cost		404.6983
Upper	181.8826	<------	Upper	163.9014	<------
E2131	-199.2942		E2132	-154.2161	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		381.1768	Reduced Cost		318.1175
Upper	230.2417	<------	Upper	204.3674	<------
E2133	-186.6229		E2211	-46.0458	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		416.8646	Reduced Cost		250.4132
Upper	192.5528	<------	Upper	260.2608	<------
E2212	-22.7418		E2213	-9.7916	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		215.2945	Reduced Cost		270.0524
Upper	181.8826	<------	Upper	163.9014	<------
E2221	-161.1721		E2222	-103.0979	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		343.0547	Reduced Cost		266.9993
Upper	230.2417	<------	Upper	181.8826	<------
E2223	-138.8002		E2231	-148.8993	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		369.0418	Reduced Cost		330.7819
Upper	163.9014	<------	Upper	230.2417	<------
E2232	-119.6476		E2233	-150.8529	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		283.5490	Reduced Cost		381.0946

COST ANALYSIS: NWHI Bottomfish Model - Version 1

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	1,156.0086	K2---	Upper	598.1993	K2---
E2311	181.8826		E2312	163.9014	
Lower	16.8026	E2331	Lower	18.5232	E2322
Reduced Cost		0.0000	Reduced Cost		0.0000
Upper	701.0692	K2---	Upper	181.8826	<------
E2313	230.2417		E2321	-30.5680	
Lower	0.0000	E2--3	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		212.4506
Upper	163.9014	<------	Upper	230.2417	<------
E2322	18.5232		E2323	-21.5594	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		145.3782	Reduced Cost		251.8011
Upper	181.8826	<------	Upper	163.9014	<------
E2331	16.8026		E2332	-5.9840	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		165.0800	Reduced Cost		169.8854
Upper	230.2417	<------	Upper	986.6525	<------
E2333	-33.2388		E3111	330.6795	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		263.4805	Reduced Cost		655.9730
Upper	897.0652	<------	Upper	1,132.6515	<------
E3112	275.9072		E3113	389.8258	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		621.1580	Reduced Cost		742.8257
Upper	802.1874	<------	Upper	662.0097	<------
E3121	20.9964		E3122	62.0826	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		781.1909	Reduced Cost		599.9271
Upper	886.3745	<------	Upper	802.1874	<------
E3123	18.0963		E3131	96.1205	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		868.2782	Reduced Cost		706.0669
Upper	662.0097	<------	Upper	886.3745	<------
E3132	26.9602		E3133	3.2259	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		635.0495	Reduced Cost		883.1487

COST ANALYSIS: NWHI Bottomfish Model - Version 1

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	988.9924	<------	Upper	817.1126	<------
E3141	515.3325		E3142	290.4294	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		473.6600	Reduced Cost		526.6832
Upper	1,037.1616	<------	Upper	859.7266	<------
E3143	229.9473		E3211	14.1483	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		807.2143	Reduced Cost		845.5783
Upper	735.3293	<------	Upper	963.1944	<------
E3212	16.7100		E3213	56.4842	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		718.6192	Reduced Cost		906.7102
Upper	802.1874	<------	Upper	662.0097	<------
E3221	-160.3775		E3222	-106.8165	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		962.5649	Reduced Cost		768.8262
Upper	886.3745	<------	Upper	802.1874	<------
E3223	-144.7195		E3231	-133.9948	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		1,031.0940	Reduced Cost		936.1822
Upper	662.0097	<------	Upper	886.3745	<------
E3232	-130.8879		E3233	-160.1084	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		792.8976	Reduced Cost		1,046.4830
Upper	809.1458	<------	Upper	667.7872	<------
E3241	44.0100		E3242	-22.5969	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		765.1358	Reduced Cost		690.3842
Upper	891.9913	<------	Upper	1,217.4188	E3341
E3243	-71.3412		E3311	802.1874	
Lower	UNBOUNDED		Lower	438.9023	E3331
Reduced Cost		963.3325	Reduced Cost		0.0000
Upper	756.7164	E3342	Upper	UNBOUNDED	
E3312	662.0097		E3313	886.3745	
Lower	313.6762	E3322	Lower	678.7495	E3343
Reduced Cost		0.0000	Reduced Cost		0.0000

COST ANALYSIS: NWHI Bottomfish Model - Version 1

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	802.1874	<------	Upper	662.0097	<------
E3321	291.1727		E3322	313.6762	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		511.0147	Reduced Cost		348.3335
Upper	886.3745	<------	Upper	802.1874	<------
E3323	260.6283		E3331	438.9023	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		625.7462	Reduced Cost		363.2851
Upper	662.0097	<------	Upper	886.3745	<------
E3332	262.0921		E3333	246.5302	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		399.9176	Reduced Cost		639.8444
Upper	UNBOUNDED		Upper	UNBOUNDED	
E3341	1,217.4188		E3342	756.7164	
Lower	802.1874	<------	Lower	662.0097	<------
Reduced Cost		-415.2314	Reduced Cost		-94.7067
Upper	886.3745	<------	Upper	1,282.3952	E4123
E3343	678.7495		E4111	1,134.1302	
Lower	UNBOUNDED		Lower	1,118.2156	Q-24-
Reduced Cost		207.6250	Reduced Cost		0.0000
Upper	1,068.7277	<------	Upper	1,255.7511	Q-24-
E4112	938.7465		E4113	1,234.5037	
Lower	UNBOUNDED		Lower	1,036.5570	E4123
Reduced Cost		129.9812	Reduced Cost		0.0000
Upper	694.6496	<------	Upper	726.7457	E4142
E4121	498.2259		E4122	508.7176	
Lower	UNBOUNDED		Lower	448.2546	E4132
Reduced Cost		196.4237	Reduced Cost		0.0000
Upper	647.7590	<------	Upper	710.5642	Q-24-
E4123	449.8123		E4131	694.6496	
Lower	UNBOUNDED		Lower	546.3846	E4123
Reduced Cost		197.9467	Reduced Cost		0.0000
Upper	508.7176	<------	Upper	647.7590	<------
E4132	448.2546		E4133	437.9753	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		60.4630	Reduced Cost		209.7837

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	UNBOUNDED		Upper	UNBOUNDED	
E4141	1,709.3951		E4142	1,096.2721	
Lower	1,139.7050	<-------	Lower	878.2439	<------
Reduced Cost		-569.6901	Reduced Cost		-218.0282
Upper	1,212.9067	E1122	Upper	811.4596	<------
E4143	1,007.0031		E4211	247.4538	
Lower	985.7557	Q-24-	Lower	UNBOUNDED	
Reduced Cost		0.0000	Reduced Cost		564.0058
Upper	657.5632	<------	Upper	803.7104	<------
E4212	212.6759		E4213	300.7376	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		444.8873	Reduced Cost		502.9728
Upper	694.6496	<------	Upper	508.7176	<------
E4221	-9.8439		E4222	35.5927	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		704.4935	Reduced Cost		473.1249
Upper	647.7590	<------	Upper	694.6496	<------
E4223	-6.2721		E4231	50.0442	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		654.0311	Reduced Cost		644.6055
Upper	508.7176	<------	Upper	647.7590	<------
E4232	6.0861		E4233	-19.5615	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		502.6315	Reduced Cost		667.3205
Upper	708.7759	<------	Upper	520.4465	<------
E4241	389.1131		E4242	219.4137	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		319.6628	Reduced Cost		301.0329
Upper	659.1616	<------	Upper	694.6496	<------
E4243	163.0250		E4311	-52.5307	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		496.1367	Reduced Cost		747.1804
Upper	508.7176	<------	Upper	647.7590	<------
E4312	-32.9716		E4313	-15.1785	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		541.6892	Reduced Cost		662.9375

COST ANALYSIS: NWHI Bottomfish Model - Version 1

Variable	Stable Cost Range	Variable to Change	Variable	Stable Cost Range	Variable to Change
Upper	694.6496	<------	Upper	508.7176	<------
E4321	-181.7364		E4322	-124.4771	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		876.3861	Reduced Cost		633.1947
Upper	647.7590	<------	Upper	694.6496	<------
E4323	-160.5767		E4331	-168.0418	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		808.3357	Reduced Cost		862.6914
Upper	508.7176	<------	Upper	647.7590	<------
E4332	-143.5105		E4333	-174.3575	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		652.2280	Reduced Cost		822.1165
Upper	694.6496	<------	Upper	508.7176	<------
E4341	-57.5709		E4342	-77.2492	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		752.2205	Reduced Cost		585.9668
Upper	647.7590	<------	Upper	-45071.3368	<------
E4343	-122.5137		K1---	-75000.0000	
Lower	UNBOUNDED		Lower	UNBOUNDED	
Reduced Cost		770.2727	Reduced Cost		29,928.6632
Upper	-30776.2196	<------	Upper	UNBOUNDED	
K2---	-60000.0000		K3---	-75000.0000	
Lower	UNBOUNDED		Lower	-165546.724	<------
Reduced Cost		29,223.7804	Reduced Cost		-90,546.7244
Upper	UNBOUNDED				
K4---	-50000.0000				
Lower	-105744.520	<------			
Reduced Cost		-55,744.5200			

Constraint at limit	Value	Constraint at limit	Value
Q-11- <	94,000.0000	Q-14- <	192400.0000
Increases objective ... by	1.2109	Increases objective ... by	0.8669
Upper Limit.		Upper Limit.	
New limit ..	103056.4786	New limit ..	200145.0937
New optimum ...	2094410.386	New optimum ...	2090158.368
Forced to limit	E4131	Forced to limit	E4131
Lower Limit.		Lower Limit.	
New limit ..	87,664.9140	New limit ..	186982.2392
New optimum ...	2075772.999	New optimum ...	2078747.323
Forced to limit	E4111	Forced to limit	E4111
Q-21- <	62,750.0000	Q-24- <	125600.0000
Increases objective ... by	0.3913	Increases objective ... by	0.0335
Upper Limit.		Upper Limit.	
New limit ..	76,630.4519	New limit ..	126131.6098
New optimum ...	2088875.347	New optimum ...	2083461.832
Forced to limit	E4131	Forced to limit	E1141
Lower Limit.		Lower Limit.	
New limit ..	53,040.5025	New limit ..	117296.4450
New optimum ...	2079644.807	New optimum ...	2083166.262
Forced to limit	E4111	Forced to limit	E4111
E1--1 <	0.0000	E1--2 <	0.0000
Increases objective ... by	378.4099	Increases objective ... by	197.3221
Upper Limit.		Upper Limit.	
New limit ..	21.2592	New limit ..	25.6045
New optimum ...	2091488.747	New optimum ...	2088496.376
Forced to limit	E4111	Forced to limit	E4111
Lower Limit.		Lower Limit.	
New limit ..	-1.3611	New limit ..	-1.6392
New optimum ...	2082929.011	New optimum ...	2083120.588
Forced to limit	E1141	Forced to limit	E1141

MARGINAL ANALYSIS: NWHI Bottomfish Model - Version 1

Constraint at limit	Value	Constraint at limit	Value
E1--3 <	0.0000	E2--1 <	0.0000
Increases objective ... by	157.9759	Increases objective ... by	181.8826
Upper Limit.		Upper Limit.	
New limit ..	26.3373	New limit ..	180.0000
New optimum ...	2087604.712	New optimum ...	2116182.914
Forced to limit	E4111	Forced to limit	E2311
Lower Limit.		Lower Limit.	
New limit ..	-37.6512	New limit ..	-45.0000
New optimum ...	2077496.069	New optimum ...	2075259.332
Forced to limit	E4131	Forced to limit	E2311
E2--2 <	0.0000	E2--3 <	0.0000
Increases objective ... by	163.9014	Increases objective ... by	230.2417
Upper Limit.		Upper Limit.	
New limit ..	403.7383	New limit ..	372.4138
New optimum ...	2149617.328	New optimum ...	2169189.220
Forced to limit	E2312	Forced to limit	E2313
Lower Limit.		Lower Limit.	
New limit ..	-100.9346	New limit ..	-93.1034
New optimum ...	2066900.728	New optimum ...	2062007.755
Forced to limit	E2312	Forced to limit	E2313
E3--1 <	0.0000	E3--2 <	0.0000
Increases objective ... by	802.1874	Increases objective ... by	662.0097
Upper Limit.		Upper Limit.	
New limit ..	1,291.8539	New limit ..	2,880.3758
New optimum ...	3119752.969	New optimum ...	3990280.716
Forced to limit	E3311	Forced to limit	E3312
Lower Limit.		Lower Limit.	
New limit ..	-194.6629	New limit ..	-434.0292
New optimum ...	1927287.909	New optimum ...	1796112.495
Forced to limit	E3311	Forced to limit	E3312

Constraint at limit	Value	Constraint at limit	Value
E3--3 <	0.0000	E4--1 <	0.0000
Increases objective ... by	886.3745	Increases objective ... by	694.6496
Upper Limit.		Upper Limit.	
New limit ..	2,187.2404	New limit ..	85.1441
New optimum ...	4022158.185	New optimum ...	2142589.388
Forced to limit	E3313	Forced to limit	E4131
Lower Limit.		Lower Limit.	
New limit ..	-1,345.9941	New limit ..	-24.9530
New optimum ...	890389.1944	New optimum ...	2066110.486
Forced to limit	E3313	Forced to limit	E4131
E4--2 <	0.0000	E4--3 <	0.0000
Increases objective ... by	508.7176	Increases objective ... by	647.7590
Upper Limit.		Upper Limit.	
New limit ..	189.1817	New limit ..	13.0739
New optimum ...	2179684.082	New optimum ...	2091912.794
Forced to limit	E4122	Forced to limit	E4111
Lower Limit.		Lower Limit.	
New limit ..	-96.1761	New limit ..	-18.6901
New optimum ...	2034517.550	New optimum ...	2071337.344
Forced to limit	E4122	Forced to limit	E4131

Updating Spreadsheet: C:BTM1.WKS(83VA)

APPENDIX - ITEM D4: BTM1 VARIABLE AND PARAMETER LISTING

RBT1 VARIABLE	SOLUTION FISH DAYS	CATCH RATE (q)	PRICE (p)	OPERATE COST (c)	ANNUAL FIXED COST PER BOAT
E1111		180	3.66	272	
E1112		230	2.35	217	
E1113	99	241	2.88	244	
E1121		83	4.53	324	
E1122		106	3.32	259	
E1123		110	3.08	292	
E1131		109	4.40	342	
E1132		92	3.56	273	
E1133		110	3.09	308	
E1141	1	255	3.85	381	
E1142		212	3.08	305	
E1143		206	3.05	343	
E1211		276	1.88	272	
E1212		352	1.21	217	
E1213	170	369	1.48	244	
E1221		128	2.33	324	
E1222		162	1.71	259	
E1223		168	1.59	292	
E1231		167	2.26	342	
E1232		142	1.83	273	
E1233		168	1.59	308	
E1241	112	391	1.98	381	
E1242	253	324	1.58	305	
E1243		315	1.57	343	
E1311		98	2.48	272	
E1312		125	1.60	217	
E1313		131	1.96	244	
E1321		45	3.08	324	
E1322		58	2.26	259	
E1323		60	2.09	292	
E1331		59	2.99	342	
E1332		50	2.42	273	
E1333		60	2.10	308	
E1341		139	2.61	381	
E1342		115	2.09	305	
E1343		112	2.07	343	
E2111		21	4.93	217	
E2112		26	3.17	163	
E2113		28	3.89	190	
E2121		10	6.11	259	
E2122		12	4.48	194	
E2123		13	4.16	227	
E2131		12	5.93	273	
E2132		11	4.79	205	
E2133		13	4.17	239	

E2211		57	2.98	217
E2212		73	1.91	163
E2213		77	2.35	190
E2221		27	3.69	259
E2222		34	2.71	194
E2223		35	2.51	227
E2231		35	3.58	273
E2232		29	2.90	205
E2233		35	2.52	239
E2311	45	123	3.24	217
E2312	101	157	2.08	163
E2313	93	164	2.56	190
E2321		57	4.02	259
E2322		72	2.95	194
E2323		75	2.74	227
E2331		74	3.90	273
E2332		63	3.15	205
E2333		75	2.74	239
E3111		152	3.95	272
E3112		194	2.54	217
E3113		203	3.12	244
E3121		70	4.90	324
E3122		89	3.59	259
E3123		93	3.33	292
E3131		92	4.76	342
E3132		78	3.85	273
E3133		93	3.34	308
E3141		215	4.16	381
E3142		179	3.33	305
E3143		174	3.30	343
E3211		147	1.94	272
E3212		187	1.25	217
E3213		196	1.53	244
E3221		68	2.41	324
E3222		86	1.77	259
E3223		90	1.64	292
E3231		89	2.34	342
E3232		75	1.89	273
E3233		90	1.64	308
E3241		208	2.05	381
E3242		173	1.64	305
E3243		168	1.62	343
E3311	195	389	2.76	272
E3312	434	495	1.78	217
E3313	1346	519	2.18	244
E3321		180	3.42	324
E3322		228	2.51	259
E3323		237	2.33	292
E3331		235	3.32	342
E3332		199	2.69	273
E3333		237	2.34	308
E3341	372	550	2.91	381

E3342	829	457	2.33	305	
E3343		444	2.30	343	
E4111	17	363	3.80	244	
E4112		462	2.44	190	
E4113	132	485	3.00	217	
E4121		168	4.71	292	
E4122	96	213	3.45	227	
E4123		221	3.20	259	
E4131	25	219	4.57	308	
E4132		186	3.69	239	
E4133		221	3.21	273	
E4141	88	513	4.00	343	
E4142	200	426	3.20	267	
E4143	149	414	3.17	305	
E4211		299	1.65	244	
E4212		380	1.06	190	
E4213		399	1.30	217	
E4221		138	2.04	292	
E4222		175	1.50	227	
E4223		182	1.39	259	
E4231		180	1.98	308	
E4232		153	1.60	239	
E4233		182	1.39	273	
E4241		422	1.73	343	
E4242		351	1.39	267	
E4243		341	1.37	305	
E4311		71	2.71	244	
E4312		90	1.74	190	
E4313		95	2.14	217	
E4321		33	3.36	292	
E4322		42	2.46	227	
E4323		43	2.29	259	
E4331		43	3.26	308	
E4332		36	2.64	239	
E4333		43	2.29	273	
E4341		100	2.85	343	
E4342		83	2.28	267	
E4343		81	2.26	305	
K1---	3				75000
K2---	1.5				60000
K3---	15				75000
K4---	4				50000

PROFIT $2,083,444